Healthcare on the move

Treating Patients in the Community: The Smart Pods Project

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Visit www.smartpods.co.uk for more information

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Foreword

Smart Pods is the first-ever Royal College of Art (RCA)/ Engineering and Physical Sciences Research Council (EPSRC) multi-disciplinary healthcare project. It has grown out of the College's chartered commitment to engage with 'social developments' through design – a commitment which has led to the establishment of our pioneering Helen Hamlyn Research Centre and, further back in time, to our celebrated 'NHS bed' design research project for the King's Fund. This brought together designers, clinicians, medical researchers and technologists in a redesign of the hospital bed, resulting in a new research and design methodology for healthcare. It also embodied our firm belief that a surprising number of healthcare issues are, at base, design issues as well.

Smart Pods builds on a project originated by the National Patient Safety Agency (NPSA), which addressed patient safety and clinical functionality in emergency ambulances. This resulted in a design specification for a national standard ambulance. Smart Pods takes the idea one step further by investigating future social, clinical and practical scenarios with a focus on treating patients more effectively in the community.

The Smart Pods team includes designers and researchers from the RCA (Vehicle Design and the Helen Hamlyn Centre), ergonomists from Loughborough University (Healthcare Ergonomics and Patient Safety Unit), specialists in operations management and procurement from the University of Bath, clinicians from the University of the West of England, and social scientists from the University of Plymouth.

Collaborating NHS partners include University Hospital Bristol NHS Foundation Trust, University Hospital Leicester NHS Foundation Trust, BrisDoc, Leicestershire County and Rutland Primary Care NHS Trust, Great Western Ambulance Service NHS Trust and East Midlands Ambulance Service NHS Trust.

Phase Two of Smart Pods will build on this multi-disciplinary research, by developing radical new vehicle typologies, clinical methods and service delivery to produce practical healthcare design solutions.

The Royal College of Art's Charter, granted in summer 1967, emphasises 'the principles and practice of art and design in their relation to industrial and commercial processes and social developments and other subjects relating thereto'. At last we are honouring that commitment, as a College. And Healthcare On The Move is one of the results.

Sir Christopher Frayling
Rector
Royal College of Art

The Smart Pods study is truly innovative. Crucially, the research has been grounded in reality through collaboration and engagement with clinical end users. It is the first to examine how Emergency Care Practitioners (ECPs) and similarly skilled pre-hospital clinicians operate, how they interface with the wider ambulance team, the equipment they need, and the treatment spaces and vehicles they use.

Through the introduction of new clinical roles, such as the ECP, the ambulance service has recognised that there is huge scope to meet urgent care needs in new ways that are more suitable for the clinical needs of patients. We are now identifying earlier, patients who would benefit from an alternative response and intervention, and almost all ambulance trusts have now developed either ECPs or similarly skilled pre-hospital clinicians to spearhead this change in service delivery. However, until now, very little thought has been given to the ways technology can improve the clinical delivery of the services provided by urgent healthcare professionals to patients.

We welcome this important area of research and look forward to developing these concepts and systems further to bring the innovative solutions contained in this study into the reality of everyday clinical practice and delivery.

Dave Whiting
Director of Operations
East Midlands Ambulance Service NHS Trust

Increasingly, health policy makers are looking for evidenced-based decisions to inform choices about where to invest in technologies. This means that supply management in the NHS is required, not only to demonstrate value from all its processes, but to provide a robust evidence base for its decision-making, prompting the procurement function to look beyond traditional boundaries for excellence and innovation. In this climate, there is a growing need to seek out research excellence and to develop a thriving and challenging research culture for NHS supply management.

But research and evidence on their own are not enough to ensure uptake of new technologies. Early engagement with stakeholders is vital to ensure that solutions developed are adopted into clinical practice.

In exploring new mobile treatment solutions to bring care closer to patients' homes, Smart Pods has recognised the importance of procurement from the outset, successfully integrating policy, innovation, design, clinical and procurement perspectives and engaging widely with stakeholders. The findings will be important in driving a reinvention of the urgent care pathway and for informing policy as well as clinical and procurement decisions for the benefit of patients.

Samantha Forrest
Head of Research
NHS Purchasing and Supply Agency

Summary

Emergency Care Practitioners (ECPs) are a new group of healthcare professionals, drawn from a paramedic or nursing background and trained with additional skills to take healthcare to the community. They are effective in their new role, reducing hospital visits and achieving high levels of patient satisfaction. However, ECPs have not been equipped with supportive technologies to optimise performance. In effect, urgent care is being delivered by 21st century professionals using 20th century vehicles and kit.

In recent years, there has been a shift in policy towards the delivery of healthcare in the community, close to the patient's home wherever possible. Increasing specialisation and centralisation of a small minority of rarer but important conditions (such as heart attack, stroke and major trauma) has been accompanied by moves towards community delivery for the vast majority of routine and urgent healthcare.

Patients prefer to be treated close to home, and value locally accessible services. For this reason, a policy of 'localised where possible, centralised where necessary', has been emphasised in the recent 'Darzi review' (2007) and been increasingly adopted by UK healthcare services.

Millions of pounds have been invested in the creation of the role of ECPs and the expansion of a wide range of other healthcare professionals. New initiatives have seen nursing staff from hospital and primary care backgrounds delivering community based care, staffing Walk-In Centres as well as delivering healthcare in the patient's home. There is a coherent and sustained shift in healthcare policy, service delivery and professional roles driving the community delivery of urgent care.

Yet, despite the considerable progress and investment in resources to date, there has been little consideration of the enabling and supporting technologies required to facilitate change. Community-based urgent care practitioners commonly work ad hoc, from crowded and disorganised equipment bags stored in the boot of a car, without a defined treatment space or tested systems of working. The true potential and long-term benefits of these exciting changes will not be realised whilst a new model of distributed urgent healthcare remains inadequately supported by appropriately designed and tested technologies.

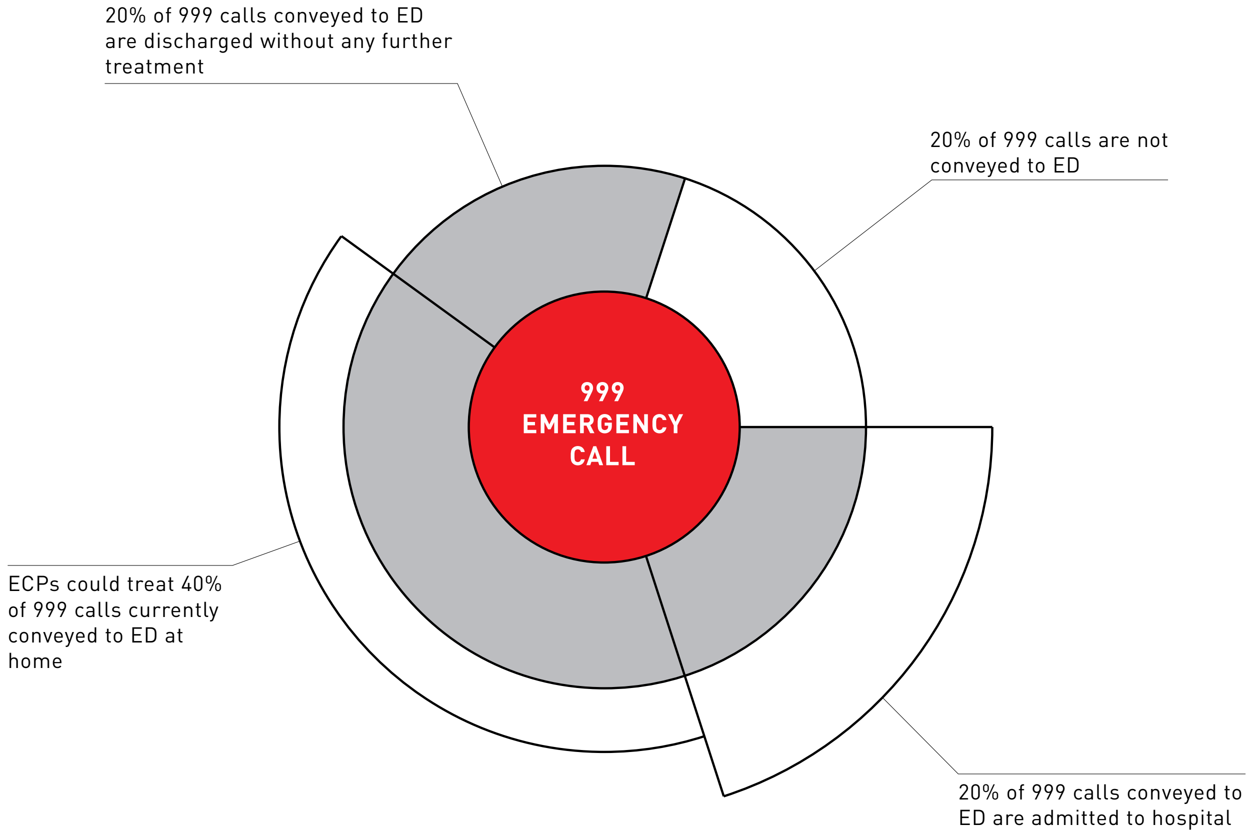


Figure 1
A breakdown of 999 calls and the likelihood of conveyance to an emergency department and admission to hospital in 2005 (Department of Health)

Main Findings of the Project

1) Forming the team
This is a complex problem that can only be effectively addressed by an experienced multidisciplinary team. If a project output is to be successfully adopted into clinical practice, then the problems and consequent solutions must be viewed from all possible perspectives, including those of patients, public, front-line clinical staff, healthcare managers, operational managers and commissioners.

2) A complex product and system
Ambulance services comprise complex interaction between a product (the vehicle), its associated technologies and consumables, support staff and technologies (for example, call centres), and front-line clinical care. Therefore, design options are intimately linked with service options, with a vital stakeholder being front-line service providers. Within front-line concerns are many discrete issues (ease of cleaning, stock control, operator comfort as well as enhanced safety, movement through traffic, wider issues of standardisation etc).

3) Policy versus design
Vital commissioning decisions will be taken at ministerial, national and regional levels; far away from the concerns of front-line staff. Does design dictate strategy (policy), or will policy dictate design? If the two are, as is most likely, interrelated and interactive, what is the optimum mix of design or policy leadership? Issues of innovation and the application of technology in the public sector, procurement, deployment and transition are critical here, and have been examined in detail in this work, alongside data and knowledge from other relevant sectors such as retail, telecommunications and the armed forces.

The Smart Pods vision responds to many trends in policy that call for reconfiguration of urgent care. However, there is a broader theme that goes beyond 'centralisation of treatment versus decentralisation'. This is about new levels of autonomy and new configurations offering alternatives to a view of healthcare that is site specific or speciality-centred.

4) Clinical activites
A series of iterative data collection and analysis steps have produced robust findings, grounded in current and future clinical activities, together with initial design ideas for both the treatment space and the packages of equipment and consumables.

5) Further opportunities
How will the Smart Pods vision be incorporated into the wider health and social care domain? For example, how will a change in the configuration of urgent care delivery engage with the broader issues such as NHS planning, the future shape and boundaries of the NHS, sociological concerns regarding the potential impact on current roles and identities; requirements for clinical training, new community facilities, planning national throughputs and facilities at hospitals?

6) Options and design solutions
New designs have to meet a range of experiential requirements, reflecting the iconic status of ambulances; they are symbols on the landscape, totems of healthcare provision in the UK. The physical form of future vehicles must give confidence to the public and clinical staff, and be packaged to provide a higher level of care than the vehicles they replace.

Introduction

Smart Pods is a two-year study that culminates in an exhibition at the Royal College of Art, during 2009. Smart Pods explores new mobile treatment solutions that will enable ECPs and other healthcare professionals to assess and treat more people in the community, instead of taking them by ambulance to hospital. Up to 50% of patients currently taken to hospital following a 999 call could be treated at home if the correct supporting and enabling technologies were in place.

Smart Pods is funded by the Engineering and Physical Science Research Council (EPSRC) and aims to design and develop a multi-level component system using enabling technologies to bridge the gap between the community and hospital provision of urgent care.

The multi-level system comprises three layers:

1) A purpose-designed treatment space in which urgent care can be effectively delivered

2) Treatment packages of equipment and consumables that can be deployed both within and beyond the treatment space

3) A vehicle system that makes the above components fully mobile within a community

This new platform for care delivery has the potential to reinvent the urgent treatment pathway by taking the emergency department and minor injuries unit to the patient.

The key outputs from 'Phase 1', the initial two years of the Smart Pods project are presented in this report. During this time we have laid the groundwork to achieve our aims through the following achievements:

1) The creation and consolidation of a novel interdisciplinary team which effectively integrates expertise in:

a) The delivery of urgent care and pragmatic clinical research

b) The design and development of vehicles and medical devices

c) Ergonomics and task analysis

d) Systems and procurement

e) The wider sociological impacts of technological change

2) The acquisition of a deep understanding of the problem and its context, with inputs from a full range of stakeholders

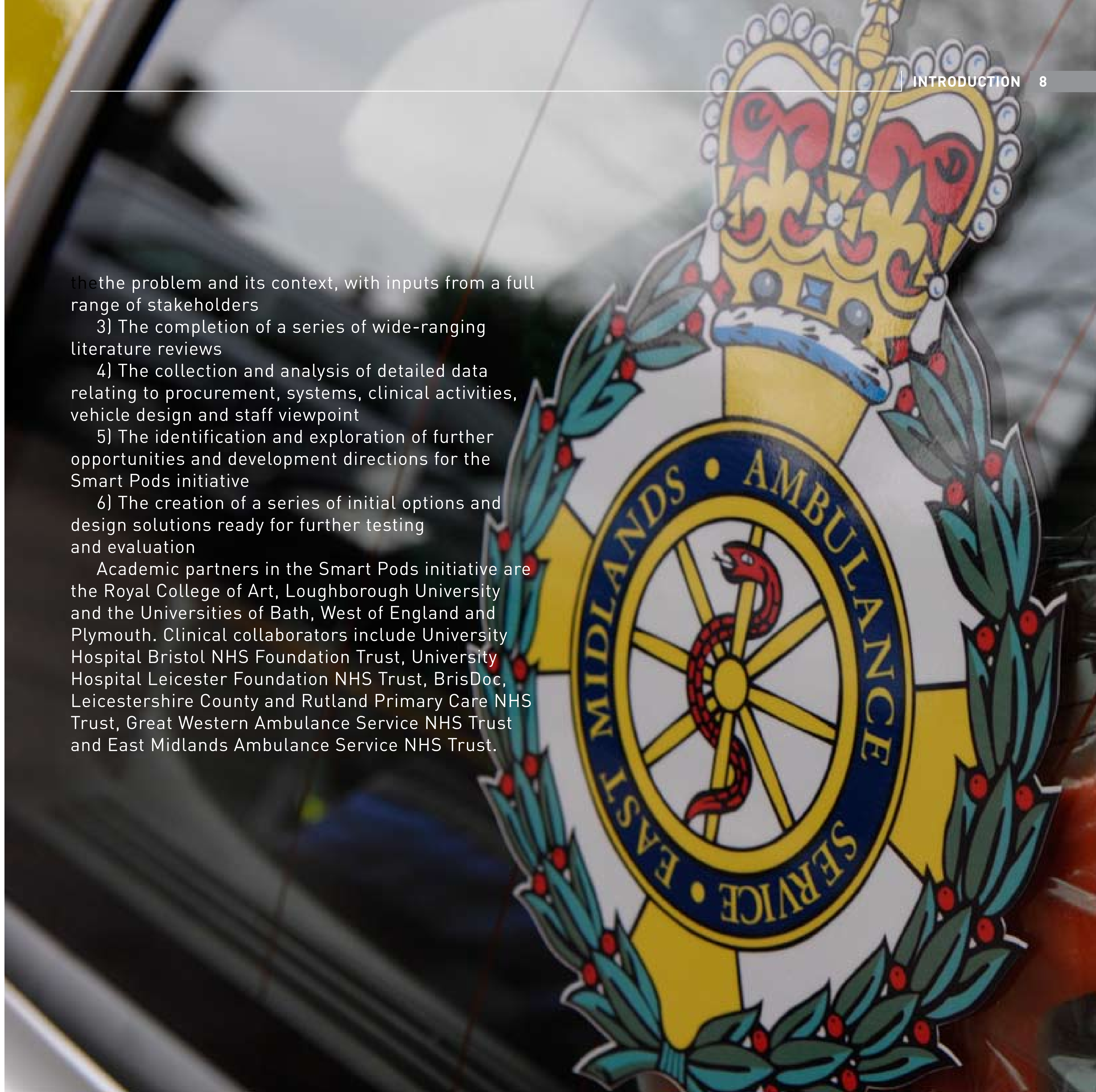
3) The completion of a series of wide-ranging literature reviews

4) The collection and analysis of detailed data relating to procurement, systems, clinical activities, vehicle design and staff viewpoint

5) The identification and exploration of further opportunities and development directions for the Smart Pods initiative

6) The creation of a series of initial options and design solutions ready for further testing and evaluation

Academic partners in the Smart Pods initiative are the Royal College of Art, Loughborough University and the Universities of Bath, West of England and Plymouth. Clinical collaborators include University Hospital Bristol NHS Foundation Trust, University Hospital Leicester Foundation NHS Trust, BrisDoc, Leicestershire County and Rutland Primary Care NHS Trust, Great Western Ambulance Service NHS Trust and East Midlands Ambulance Service NHS Trust.



1. 999 Call

The 999 telephone number has been in use in the UK since 1937. The number of calls has risen dramatically in recent years, greatly increasing demand on the NHS. This section includes:

- 999 Call overview
- Ambulance trusts
- Targeted healthcare solutions
- Case study – Virgin Atlantic: service innovation

2. Resp-onse

Once the 999 call is received by the ambulance service call taker, a response is set in motion. Systems are in place to ensure accurate and appropriate responses to all types of call. This section includes:

- Response overview
- Mapping patient scenarios
- The system design challenges
- Case study – RAC: Unscheduled roadside care

3. Mobi-lity

The ambulance service relies on a range of vehicle types to enable pre-hospital clinicians to attend calls rapidly and safely. Vehicles are equipped to suit the skill of the clinician. This section includes:

- Mobility overview
- NPSA future ambulances project
- Typology of ambulance vehicles
- A day in the life of...
- Overview of ambulance vehicles
- Improving the existing ambulance
- The hardware design challenge
- Design platforms
- Traffic Light model
- Royal College of Art Masters Vehicle Design
- Case study –Tesco: Zero-emissions delivery fleet

4. Treat-ment

Emergency Care Practitioners are trained to carry out a wide range of medical procedures on-scene, to reduce the demand on accident and emergency departments. This section includes:

- Treatment overview
- Treatment system ergonomics
- What happens in...
- Treatment space package
- Mobile treatment space
- Portable treatment packages
- Typology of portable equipment
- Case study – Army: Military medical protocols

1.
999 Call

There were 7.2 million emergency and urgent calls in England during 2007/08, 5.9 million of which resulted in an emergency response and 4.26 million required a patient journey.

999 Call Overview

Background
In 1937, London launched the first dedicated emergency telephone number. Dialling 999 from a telephone triggered a red light and buzzer in the operator exchange. By the 1970s this service was available from every telephone in the UK. Today, the ambulance service receives more than six million emergency telephone calls each year; twice as many as a decade ago.

However, most 999 calls do not lead to hospital admission, and many patients currently conveyed by ambulance are discharged from the emergency department within four hours of arrival. A substantial proportion of these patients could be successfully treated in the community and closer to home, if the correct services and supporting technologies were in place. This is the problem that Smart Pods is currently addressing.

Pan-European emergency number
The European Union (EU) adopted 112 as a common emergency telephone number in 1991. This service works alongside each country's local emergency number and can be called free of charge from landlines and mobile telephones. Each year there are around 100 million medical emergencies reported in the EU (EUROPA, 2008).

By the end of 2009, all new vehicles could be equipped with automatic emergency call (eCall) technology as part of the EU's eSafety initiative. The eCall technology will alert the emergency services in the event of a road traffic collision and is projected to save around 2,000 lives each year (EUROPA, 2008).

Ambulance Trusts

In England, NHS Ambulance Trusts are responsible for providing emergency access to NHS healthcare services and in some cases provide transport for patients to get to hospital. There are currently 12 Ambulance Trusts, defined by geographic location.

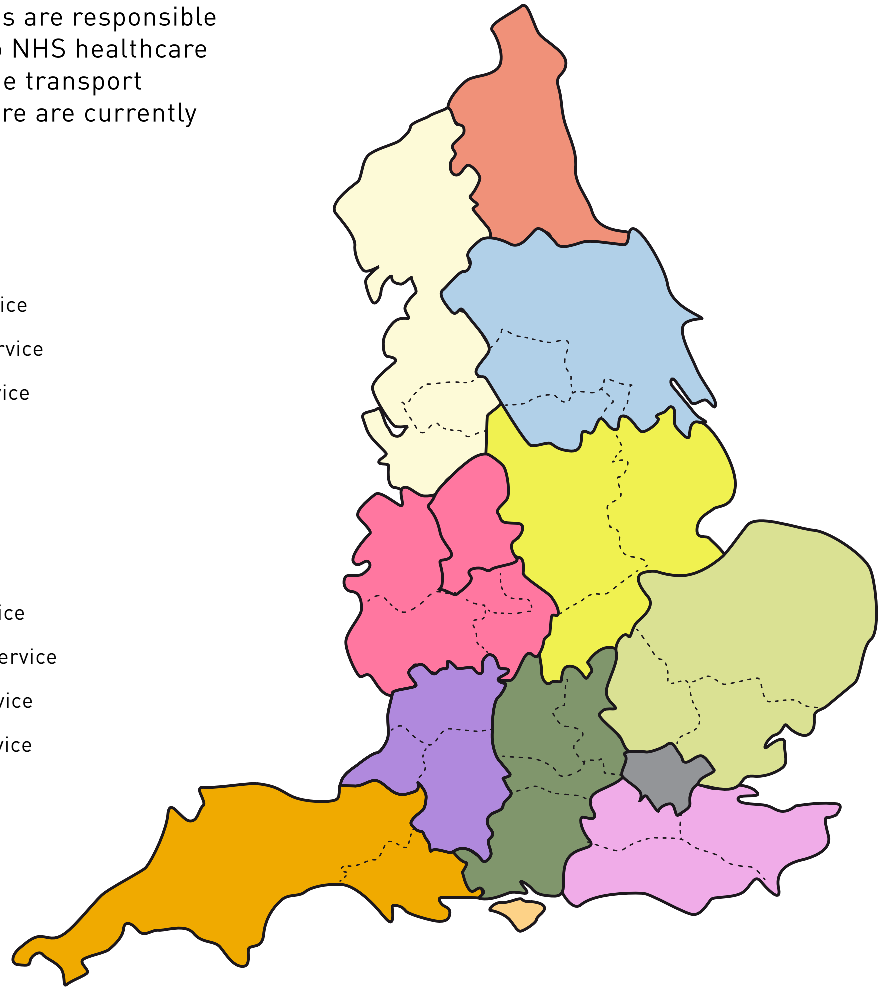


Figure 2
A map of the geographic area covered by each of the current 12 NHS Ambulance Trusts in England.

Targeted Healthcare Solutions

Stakeholder workshops
Stakeholders from three healthcare domains – acute, community and emergency care – participated in two workshops to identify the types of health complaints presented by patients who could be treated on-scene, rather than transported to an emergency department.

Participants were recruited from six NHS Trusts (see table 14 and table 15, page 95).

Six patient categories were identified:
- Physical minor
- Physical uncertain
- Physical major
- Social
- Mental
- Elective

Two categories had most potential for treatment on-scene: physical minor and physical uncertain.

PHYSICAL MINOR	PHYSICAL UNCERTAIN
Minor laceration	Abdominal pain (stomach ache)
Minor injury	Non-injury back pain
Cough and cold	Simple back pain
Urinary and catheter problem	Lower limb pain without impaired mobility
Eye injury, foreign body, infection	Some chest pain complaints
Minor ear, nose and throat, foreign body, infection	Falls without injury
Upper respiratory tract infection	Chronic obstructive pulmonary disorder
Diarrhoea and vomiting	Bowel problem
Animal bite	Headache
Insect bites and stings	Asthma
Minor illness	Crying babies, feeding problems
Sprains and strains	Breathing difficulty, non specific
Minor head injury	Nose bleeds
Toothache pain management	
Rashes	
Gastro intestinal upset	
Dental	

Table 1
Complaints that could be treated on-scene.

Targeted health complaints
Six health complaints were identified (see table 2, below) and 999 call data for July 2006 were analysed to establish the frequency of these calls.

999 call data are not available for neck pain and head injury because these complaints are not specifically coded for within the current AMPDS system (see Response Overview, p21).

HEALTH COMPLAINT		PATIENT CATEGORY	CATEGORY A	CATEGORY B	CATEGORY C
Br	Breathing difficulties	Physical minor	2563	646	0
Ch	Chest pain	Physical uncertain	2706	12	12
La	Laceration	Physical minor	340	59	11
Fa	Falls	Physical uncertain	504	153	72
Ne	Neck pain	Physical minor	-	-	-
He	Head injury	Physical minor	-	-	-

Table 2
Targeted health complaints and AMPDS analysis for July 2006.

Case Study

Virgin Atlantic: Service Innovation

Virgin Atlantic demonstrates the success of a customer-centred approach to experiential service innovation. It has achieved growth by listening to customers, offering unique experiences and rapidly implementing product and service innovations. Key learnings for the project include: 1) implementing innovation and 2) stakeholder consultation.

Background

Until 1984, Richard Branson was probably best known for the record label Virgin Records, which was responsible for globally successful artists, such as the Rolling Stones and Human League. That all changed when Branson announced that he planned to launch a high quality, good value and customer centered airline in collaboration with Randolph Fields.

Three months after the announcement, Virgin Atlantic was born. Branson marked the event by flying a fully crewed airline with many friends, celebrities and media to New York. By 1990 Virgin Atlantic had flown over one million long haul passengers around the world.

Funded, in part, by the sale of Virgin Records, Virgin Atlantic rapidly expanded its operations, destinations and aircraft. Today, Virgin Atlantic flies more than five million passengers each year between the UK and Africa, Asia, Australia, the Caribbean, North America and the Middle East. In total, it operates 38 wide-bodied aircraft on long haul routes between 30 airports around the world.

Virgin Atlantic has led by example in an industry that was previously dominated by established long haul airline giants. It is currently the second largest long haul carrier in the UK and the third largest North Atlantic long haul carrier in Europe.

It has won multiple awards for its innovative approach to service development, including three at the 2008 British Travel Awards for best business class, best economy class and best long haul airline.

The Virgin brand is now synonymous with a range of very different types of service industry, including music, communications, air travel and more recently, space tourism. Both innovation and the needs of the customer are at the core of Virgin Atlantic's brand value.

Customer centered and experiential service design

Virgin Atlantic is responsible for setting trends in the airline industry and has expanded the complete customer journey through multiple innovations at customer touch points that were traditionally considered outside the scope of air travel providers. It has increased the level of expectation for long haul business class travellers by taking inspiration from luxury hotels and private members' clubs.

For Virgin Atlantic business class customers it is not just about flying to a destination anymore. For example, in 1989, Virgin Atlantic was the first to offer individual television screens to all passengers in all cabins. This practice has spread to other major competing airlines.

For customers, using the Virgin Atlantic business class service, known as Upper Class, the experience begins at home or the office, where they are picked up by a chauffeur-driven car. At the airport, passengers are invited to spend time in specially created lounges, known as Virgin Atlantic Clubhouses. For example, the Virgin Atlantic flagship Clubhouse at Heathrow was designed to feel like a private member's club. Here, passengers can drink cocktails, eat at the deli or brasserie, play pool, go to the gym or spa and receive massage and other therapeutic treatments, have a hair cut, or work in the library.

At Heathrow, Virgin Atlantic has introduced a unique 'Drive Thru' service at Terminal 3 – The Upper Class Wing. The Upper Class Wing is like no other business or first-class check-in. Upper Class passengers, who will already have supplied check-in details to the driver of their chauffeured limo are taken up a ramp to a private arrival area. After being welcomed by a Virgin Atlantic host, check-in formalities are completed before passengers walk through a new hotel-style lobby area and into the dedicated security channel. From there, they are a short walk from the comfort of the Virgin Atlantic Clubhouse.

The Upper Class cabins in the aircraft are designed to ensure the on-board customer experience continues to be pleasant, enjoyable and stress-free. All of the seats in this area of the aircraft are forward facing in a herringbone design. Virgin Atlantic has one of the longest fully flat beds, which also converts into a seat, where there is space to sit and eat a meal with friends or other passengers. There is also an on-board bar where passengers can enjoy a drink and snack with other Upper Class passengers. On certain flights there is a designated 'snooze' zone for passengers who want to sleep for the duration of the flight.

Maintaining innovation

Implementing product and service innovation can be expensive. This is especially demanding in the airline industry, which has very high overheads and so must make maximum use of assets and keep aircraft in the air and off the ground as much as possible.

Joe Ferry, Head of Design and Service Design at Virgin Atlantic, says, 'it doesn't feel right for me that brand is separate to product' (Design Council, 2007). The in-house design team at Virgin Atlantic has continually achieved successful product and service innovation by commissioning multidisciplinary design consultancies, maintaining a close connection with their brand, understanding what the customer wants and going beyond the customers' expectations by delivering new and unexpected products and experiences which passengers eventually take for granted.

2. Response

East Midlands Ambulance Service responded to 630,000 emergency and urgent calls in 2007/08:

- 32% life threatening (category A)
- 39% urgent (category B)
- 29% not immediately serious (category C)

Response Overview

Advanced Medical Priority Dispatch System
The Advanced Medical Priority Dispatch System (AMPDS) is used to triage 999 calls by the ambulance service call taker. It is made up of a sequence of questions that help to assess how urgent a medical problem is (see figure, right).

First of all, the call taker will establish the location of the caller. BT landlines automatically let the call taker know the address of the caller. This information ensures that an ambulance can be dispatched, should it be required. Then a general explanation of the problem is required. This determines an initial level of response and the medical dispatch requirements.

The system is based on 32 chief complaints – chest pain, breathing difficulty, falls and so on – each of which has a different set of questions. As the call progresses computer software updates the relevant questions and severity of the call. To ensure that Category A calls are reached within the allotted eight minutes, ambulances are dispatched almost immediately and then downgraded if it becomes apparent that the 999 call is less serious than first thought. For example, certain types of call, such as a fainting, may begin as a Category A, because the person is unconscious, but is rapidly downgraded as they regain consciousness.

If a call taker is not available the call is diverted to a medical dispatcher. Alternatively, a call taker and the AMPDS may confirm that a caller does not require an ambulance, but instead requires consultation by phone, GP to attend, or other heathcare service.

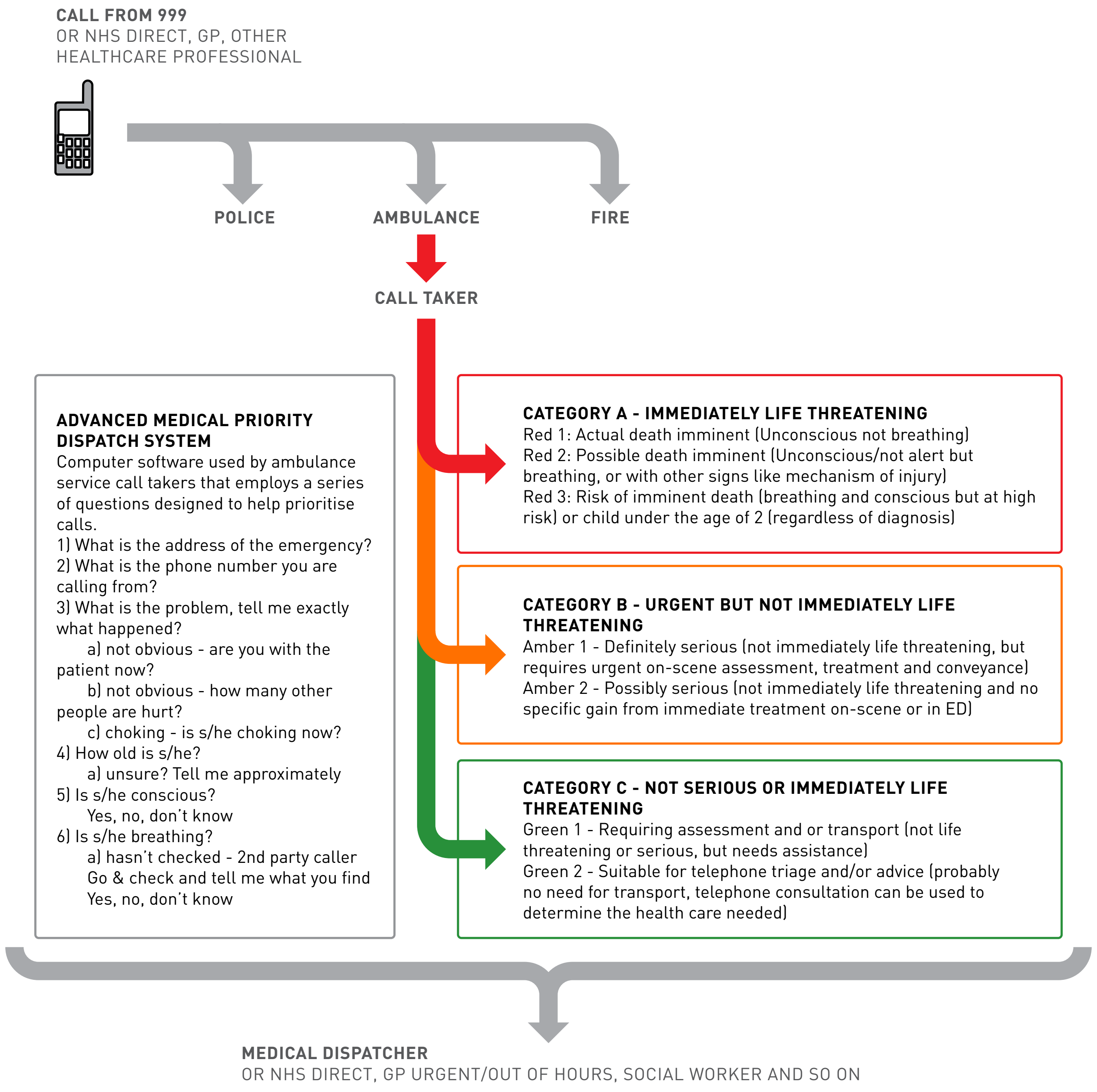
A comparison between the AMPDS category and a clinically directed dispatch system found that the clinically directed (e.g. nurse-led) dispatch system used a wider range of alternative pathways across all AMPDS categories. It was concluded that AMPDS was a poor predictor of the potential to avoid ED attendance (Gray and Walker, 2008).

Medical dispatcher
Information received by the call taker is transferred to a medical dispatcher. The computer system highlights the nearest available vehicles and it is up to the dispatcher to identify the most appropriate vehicle/s. This might be determined by the type of call, if for example a crew member has pediatric expertise and a child is the patient.

The dispatcher logs the times of acceptance by a crew and arrival on scene. It is also up to the dispatcher to manage the availability of the crews and their rest breaks.

NHS Direct
999 calls that do not require an ambulance, but have a medical requirement, may be transferred for telephone advice by NHS Direct. This is a 24 hour telephone service that provides urgent care services, response to health scares, support for patients with long-term conditions, out of hours support for GPs and dental services, pre and post operative support for patients and remote clinics via telephone.

NHS Direct call takers triage the calls and refer patients to Nurse Advisors. Alternatively, they may decide the caller requires an ambulance, in which case the patient is fast tracked to an ambulance service and emergency department.



Mapping Patient Scenarios

	ROADSIDE	GROUND FLOOR	UPPER FLOOR	OFF ROAD	PUBLIC EVENT
Br Breathing difficulties	Road traffic collision: steering wheel injury to chest	Anxiety attack in pub	Worsening emphysema	Fall from ladder: chest injury	Asthma attack at rugby match
Ch Chest Pain	Chest pain whilst driving	Chest pain following cocaine use in hostel	Sudden infant death in a block of flats	Respiratory arrest following heroin overdose in a graveyard	Chest pain whilst competing in school sports day
La Lacerations	Minor road traffic collision: laceration to right knee	Cut hand with knife whilst washing up	Bleeding from varicose veins, third floor elderly persons home	Trod on rusty nail at campsite	Nosebleed from clash of heads at football match
Fa Falls	Tripped on uneven pavement outside GP practice	Overbalanced reaching for remote control at home	Fall into pub cellar	Fall from horse in Cotswolds	Blown over by gust of wind at church fete
Ne Neck pain	Low speed rear end shunt: gradual onset neck pain	Sudden onset of severe neck pain whilst watching TV	Child woke with stiff neck, unable to look to the left	Neck pain: hit with bag containing beer cans in public park	Sudden neck pain whilst looking up at balloon festival
He Head injury	Child on bike hit by car: reduced level of consciousness	Bumped head on shelf while standing up	Slipped off toilet in the night and cut head on sink	Assaulted in massage parlour	Struck in head by firework in public display
Me Mental	Carbon monoxide overdose in own car	Acutely agitated at home	Threatening to jump from cinema roof	Preaching to Cathedral visitors	Panic attack in crowd leaving football match

Table 3
Mapping patient scenarios against complaints and environments.

	ROADSIDE	GROUND FLOOR	UPPER FLOOR	OFF ROAD	PUBLIC EVENT
Br Breathing difficulties	Paramedic 0.9 ECP 0.6 Doctor 0.3	Paramedic 0.7 ECP 0.4 Doctor 0.1	Paramedic 1.0 ECP 0.9 Doctor 0.6	Paramedic 1.0 ECP 0.9 Doctor 0.7	Paramedic 0.9 ECP 0.7 Doctor 0.5
Ch Chest Pain	Paramedic 1.0 ECP 0.9 Doctor 0.8	Paramedic 0.8 ECP 0.6 Doctor 0.5	Paramedic 1.0 ECP 1.0 Doctor 1.0	Paramedic 0.8 ECP 0.6 Doctor 0.4	Paramedic 1.0 ECP 0.9 Doctor 0.3
La Lacerations	Paramedic 0.9 ECP 0.5 Doctor 0.2	Paramedic 0.8 ECP 0.4 Doctor 0.1	Paramedic 0.8 ECP 0.5 Doctor 0.2	Paramedic 0.7 ECP 0.3 Doctor 0.1	Paramedic 0.7 ECP 0.5 Doctor 0.2
Fa Falls	Paramedic 0.7 ECP 0.4 Doctor 0.2	Paramedic 0.4 ECP 0.1 Doctor 0.1	Paramedic 0.8 ECP 0.6 Doctor 0.4	Paramedic 1.0 ECP 0.9 Doctor 0.8	Paramedic 0.6 ECP 0.4 Doctor 0.2
Ne Neck pain	Paramedic 0.7 ECP 0.4 Doctor 0.1	Paramedic 0.8 ECP 0.8 Doctor 0.8	Paramedic 0.8 ECP 0.5 Doctor 0.1	Paramedic 0.9 ECP 0.8 Doctor 0.7	Paramedic 0.8 ECP 0.6 Doctor 0.2
He Head injury	Paramedic 1.0 ECP 1.0 Doctor 1.0	Paramedic 0.7 ECP 0.3 Doctor 0.1	Paramedic 0.9 ECP 0.5 Doctor 0.2	Paramedic 0.6 ECP 0.4 Doctor 0.2	Paramedic 1.0 ECP 1.0 Doctor 1.0
Me Mental	Paramedic 1.0 ECP 1.0 Doctor 1.0	Paramedic 0.9 ECP 0.7 Doctor 0.7	Paramedic 0.9 ECP 0.7 Doctor 0.7	Paramedic 1.0 ECP 0.8 Doctor 0.8	Paramedic 0.7 ECP 0.4 Doctor 0.1

Table 4
The likelihood of patients being conveyed and admitted to hospital by paramedics, ECPs and doctors. This is determined by the ability to diagnose and treat on-scene.

The System Design Challenge

Smart Pods has identified five system design challenges that underpin the project. By addressing these design challenges Smart Pods is defined, but also contributes to shaping the future of urgent healthcare delivery.

1) What patient problems will the proposed Smart Pods manage?
Smart Pods aims to identify and manage those urgent care conditions that do not require attendance at, or admission to, a hospital, but which are sufficiently time critical to merit an urgent response by trained healthcare professionals. This patient group is both large and growing, and requires substantial changes in the way in which urgent healthcare needs are assessed and managed in the community. In particular, it is necessary to consider the ways in which the clinical activities of assessment and treatment, historically provided in fixed and centralised hospital locations, can be supplied in a more distributed way in community settings.

This requires the creation of a treatment space which can be made mobile, and which contains the equipment required to effectively and completely manage an identified patient group. Because it may not always be possible or practical to move the patient into a mobile treatment space (for example, if they are within their own home), the required equipment must itself be made mobile, so that it can be carried and used outside the treatment space.

2) How will Smart Sods fit into and augment the existing NHS infrastructure and what will they replace?
Smart Pods will be integrated into the existing urgent care system. This is most likely to occur within the ambulance service, but could also relate to primary care and other community-based urgent care services such as Walk-In Centres and Minor Injuries Units. Smart Pods will replace a significant proportion of the current ambulance response with a mobile assessment and treatment service which aims to deliver care on the spot, rather than conveying the patient to a centralised location (hospital). Smart Pods has the potential to bridge the existing gap between community-based primary care services and hospital care, ensuring that patients only attend a hospital emergency department, or are admitted to a hospital bed, when it is absolutely necessary.

3) What is the correct staff configuration (in terms of numbers, skill level and access to remote support) required to effectively assess, treat and discharge patients with the identified problems?
Because the identified patient group is not critically ill their healthcare needs can be effectively met by a single practitioner. This is because the patient should not need to be lifted or carried (indeed the required skills and equipment will be brought to them), and they will also not require simultaneous, time-critical interventions delivered by multiple healthcare professionals. However, this requires that the healthcare needs of the patient are accurately assessed at an early stage so the correct resource, in terms of both practitioner skill and supporting technologies, can be despatched to the patient in a timely manner. This is one of the greatest challenges facing the urgent care system, and currently requires that vehicles are often over-equipped in case the initial assessment (usually undertaken by telephone) proves inaccurate. Paramedic and nursing staff with additional skills, training and supporting technologies appear ideally suited to the delivery of the required care, with remote support from a senior doctor via robust communication and data links.

4) What level of standardisation (equipment and consumables) can be achieved whilst maintaining a high level of clinical functionality and patient safety?
An important outcome of the early stages of the Smart Pods initiative established that adapting vehicles on-base, in response to specific calls, is not practical. However, some degree of modularisation within the vehicle and its equipment remains appropriate, whilst allowing sufficient flexibility for regional, local and individual variations in the treatment space and equipment carried. In addition, it seems likely the basic facilities and equipment required for short-term emergency care and life support will always need to be carried by all urgent care vehicles, to meet with public and service expectations, to provide an acceptable degree of flexibility and to deal with unexpected events or patient deterioration.

5) What is the business case for adopting Smart Pods?
The business case for Smart Pods is about reducing wasted resources and recycling those wasted resources into local treatment.

Recycling wasted resources will mean less waiting, less transport, less fuel, fewer expensive attendances at emergency departments, and less wear and tear on vehicles, staff, patients and loved ones. Applying those recycled resources in the neighbourhood where they are needed most means more treatment where and when it is required.

Smart Pods will deliver better care, locally, through maximising what can be delivered in the community by highly trained staff with specialist skills, but who are also trained to recognise when additional transport to a hospital is best. All this is made possible by the enhanced support provided by vehicles and equipment designed by leading experts in making design and healthcare mobile.

Case Study

RAC: Emergency Roadside Care

Customer satisfaction is core to the success of the RAC, which currently has a renewal rate of around 80% for its emergency roadside assistance service. Key learnings include: 1) equipment, 2) infrastructure and 3) despatch.

Background

The RAC's primary business is emergency roadside assistance and it was ranked number one in this industry for 2006, 2007 and 2008 by J. D. Power. Since its formation in 1897, RAC has grown to around 7 million roadside members and attends 2.7 million breakdowns each year. RAC is an exemplar in this market and presents leading practice for roadside service delivery.

Patrols may be faced with any petrol or diesel car and increasingly they come across electric, hydrogen and hybrid vehicles, which pose new challenges. RAC provides unscheduled emergency roadside assistance to a diverse range of vehicles and customers across a wide geographic area within limited time constraints. In 2007 dispatch estimates were 75% accurate within 15 minutes and 85% accurate of job completion times.

Vehicles and equipment

Patrols rode Matchless motorbikes with sidecars equipped with tools and spares until the 1960s when the last motorbikes were phased out and replaced by vans. However, in recent years and in an attempt to overcome urban congestion, motorbikes have been reconsidered.

Currently, RAC operates a fleet of roughly 1,900 roadside assistance vehicles. These are converted Ford Transit and VW Transporters kitted out with approximately £8,000 worth of equipment, a trailer and £3,000-worth of IT. Each van is looked after by a single patrol and taken home at the end of each shift. The patrol is responsible for cleaning and maintenance, which is essential, because customers often travel in the vehicle if theirs has to be towed. The 50 or so recovery vehicles, on the other hand, are larger and more expensive and so are often part of a share scheme made up of two or three people. In addition, RAC operates a fleet of specialist patrols for manufacturers including Bentley, Porsche and VW.

Roadside recovery vans are leased and in service for five years, along with the equipment. The trailer, which is fitted into every vehicle, lasts roughly two vehicle lifetimes and so is reinstalled.

Standard assistance vans are equipped with a world leading IT system to help diagnose faults and aid communication. A Panasonic 'Toughbook' laptop provides the hub, located in the vehicle, and is connected to Control Centre using the 3G network with location-finding via GPS. The laptop can be plugged directly into some modern vehicles to assist with diagnosis. The patrol uses a portable touch screen mounted in the cab and is connected to the hub wirelessly. Key information is displayed on the touch screen relating to the initial diagnosis supplied by the Control Centre, such as images, security information and technical data. Additional information is obtained from the technical centre.

There is limited space to carry equipment and spares on the assistance vehicles. The content is rationalised to ensure the widest coverage of repairs. Typically, four of the most common battery types are carried along with belts, spark plugs and so on. RAC has a nationwide contract with a parts supplier who replenish the vehicles with stock. It is the responsibility of each patrol to maintain stock levels in their vehicles.

Optimised dispatch and rescue

RAC has three control centres located in Walsall, Glasgow and Stretford. The UK is divided into a series of 'tables' which are further divided into 'cells'. The UK is made up of 230 cells, which vary from 2 km^2 to 50 km^2, depending on population and vehicle density. Lead Patrols manage a unit of up to 15 patrols within each cell.

RAC call centres receive 4 million calls each year. To ensure the correct service is dispatched, the call taker will ascertain whether the caller is entitled to RAC assistance, the vehicle type and their location. The service has developed a range of questions to facilitate diagnosis over the telephone and help determine the most appropriate vehicle – roadside assistance van or recovery vehicle – and to provide the patrol with an initial diagnosis. Choice of vehicle is determined by the likelihood of a patrol being able to fix the problem. Every patrol vehicle is fitted with a dedicated trailer. However, in most cases the fleet is better utilisation by allocating recovery vehicles to tow breakdowns if there is a high degree of certainty that they cannot be repaired.

Location is determined by address, landmark (RAC has mapped 5.5 million on digital maps) or mobile phone signal. Between 70% and 80% of vehicle deployment is automatic. Command and control is aware of each vehicle's location and availability. In certain cases a patrol dispatch may be delayed to allow a closer patrol to attend when they become available. Job completion times are established by patrols on-scene, and are 85% accurate.

Once complete, the patrol submits a seven digit fault code to the control centre – part of vehicle, problem and action taken, such as battery flat/replaced – which is matched to vehicle type, model, year, registration and so on. Trends are observed live, and key information is fed back to the manufacturers to enable them to spot potential problems early on.

A rescue is only prioritised if the caller is believed to be in imminent danger, such as a lone female in a threatening area or a breakdown on the side of a busy motorway. These calls are manually upgraded.

Service delivery

Once a patrol is allocated, they are issued with the caller's details and an initial diagnosis. They normally contact the customer by phone to let them know they are on the way and the expected time of arrival. The average response time is 45 minutes.

Customers are updated by text message and telephone until the patrol arrives. Bad news is always conveyed by telephone. This minimises 'spiralling' caused by customers calling the control centre to check on the service during busy periods and increasing demand.

3. Mobility

East Midlands Ambulance Service attended 79% of life threatening (category A) calls within 8 minutes and 94% of urgent (category B) calls within 19 minutes in 2007/08.

Mobility Overview

Ambulance services have gradually progressed from simply conveying patients to and from hospitals, to delivering medical capability into the community and treating patients on-scene.

Hospitals began operating a dedicated ambulance service to transport sick and injured people in the 18th century. Patients were transported to and from hospital by cart and horse-drawn carriage (see figure 3, right) up to about 20 miles. Patients from rural areas were transported by train and collected from the station.

The main advantage of motor-powered vehicles, developed in the 1900s, was the ability to transport patients more quickly and over greater distances. Their adoption accelerated throughout World War I as demand for ambulances increased. Motorised ambulance fleets were established in urban areas and distributed around towns and cities.

Mobilising a treatment capabilty

It wasn't until 1946 that the National Health Service Act was passed, which required local authorities to provide ambulances 'where necessary'. Initially, ambulances were staffed by drivers with limited first aid traning.

The next major development came with the Miller Report in 1964, which recommended that ambulances should provide treatment as well as transportation. To enable ambulance staff to provide treatment, a six-week course was set up and minimum standards of equipment were established. This marked an end to ambulance vehicles solely conveying patients and the beginning of the development of highly trained paramedics, working autonomously and using a wide range of clinical procedures.

Modern ambulance services have established fleets of vehicles capable of dealing with a diverse range of patients and healthcare related problems (see Typology of Ambulance Vehicles, page 36). In recent years, there has been a shift away from sending dual-crewed ambulances (DCA) to the majority of cases. Instead, single-crewed smaller vehicles, known as fast responders, are dispatched. These vehicles tend not to be used as a treatment space or to convey patients to hospital. Instead, they are used to deliver clinical capabilities to the site of the incident.

Should a patient need to be conveyed, or if a treatment space is required, a conventional DCA is dispatched. This shift in practise is partly due to increased pressure on response times: a Category A call (see Response Overview, page 21) requires a vehicle to be on-scene within eight minutes. In 2004–05 the ambulance service attended 4.26 million 999 calls in England and 76.2% of Category A life threatening calls were reached within the eight minute target (Department of Health, 2005a). Due to increasing demand on ambulance services, Peter Bradley, National Ambulance Advisor, recommended that ambulances are not automatically sent to every call.

Establishing national safety guidelines

Until 2000, guidelines for the delivery of care were developed regionally, which resulted in variation throughout the UK, and thus quality of care was dependent on patient location. This was resolved with the development of nationally applicable clinical practice guidelines, which are reviewed biannually to meet the changing needs of the ambulance service. The development of these guidelines was fundamental to enable a patient safety design approach.

Figure 3
A horse-drawn ambulance from 1895, which was used to transport patients to and from hospital. They operated within towns and up to 20 miles from hospitals. They were in operation in England until the early 1900s when they were superceded by motor powered vehicles.

Figure 4
The Austin K8 25cwt ambulance (1948–1954) was distinguished by double door access on the nearside, offside and rear, which led to it being known as the 'three-way'. Ambulance conversions were ordered directly from the factory and were called the Welfarer K8/AA. Modifications include: increasing the track by 30 mm; altering the suspension to give a 'softer' ride by using different road springs and shock absorber settings; and the addition of low pressure tyres. The driving position was particularly good, high up and over the front axle.

NPSA Future Ambulances Project

Background

In March 2005, the National Patient Safety Agency (NPSA) prioritisation panel strongly supported a project on ambulance design to be taken forward in the coming year in response to concerns relating to the design of vehicles and equipment that impact on patient safety. In June 2005, the Department of Health set out a vision for the provision of future ambulance services by 2010. This included providing an increasing range of quality mobile healthcare services for patients with urgent and emergency care needs.

The overarching aims are that patients will receive improved care by consistently receiving the right response, first time, in time, and that more patients will be treated in the community, resulting in more effective and efficient use of NHS resources. It seems likely that these changes will require different vehicles and equipment for ambulance services.

Aim

This first scoping study aimed to investigate the developing models of service provision in the Ambulance Service, and the short and long-term requirements of vehicles and equipment needed to address the concerns of patient and staff safety in the future.

Method

Three types of data were collected: archival incident reports, research literature and empirical data from workshops. The archival data were collected from three sources about reported incidents relating to ambulance, ambulance equipment design and use, and patient and staff safety. The research literature review was used to not only set out the background context but also to develop the conceptual framework for the analysis of the workshop data. Empirical data were collected from four user workshops.

Results

A dataset of 1,352 incidents was received from the National Reporting and Learning System (NRLS) database and 1,259 were retrieved from the Manufacturer and User facility Device Experience (MAUDE) database. Ten ambulance trusts responded to a request for information (from the 32 trusts contacted).

The incidents were scrutinised individually and initially coded to provide a framework for discussion at user workshops. After the analysis of the workshop data, the incident reports were reviewed and coded into the nine design challenges. The data from the workbooks at the strategic workshop were analysed thematically to identify six core areas of service provision.

These areas of service provision were used as the discussion framework at the manufacturer and operational workshops. The data from the operational workshops were coded in two stages to allow for iterative analysis and further exploration of codes and themes. The coding by Roger Coleman/Merih Kunur resulted in two distinct design outputs for (1) design issues and (2) problems/ features. These codes were then scrutinised by Emma Crumpton, resulting in the 31 codes. At this stage a detailed secondary coding was conducted within the codes to identify nine higher level codes and address duplication between codes (Emma Crumpton/ Sue Hignett). These design challenges were further checked against the primary coding by Sue Hignett to confirm inclusiveness. The results of this study were communicated in two publications (see figure 5, right).

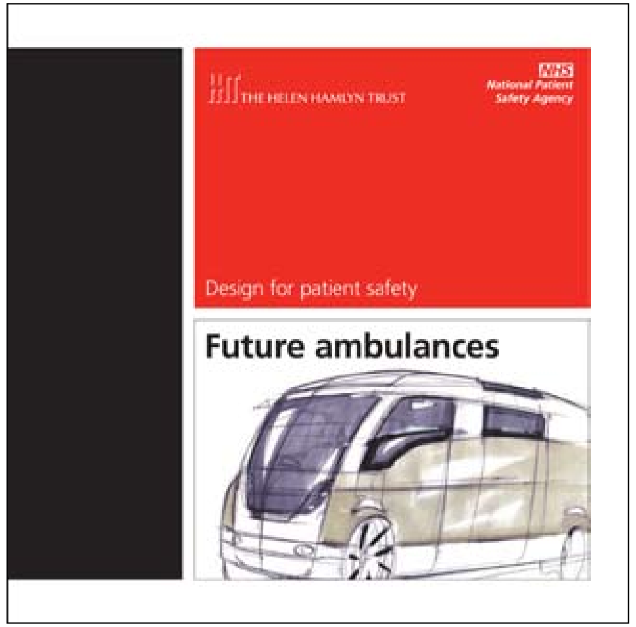
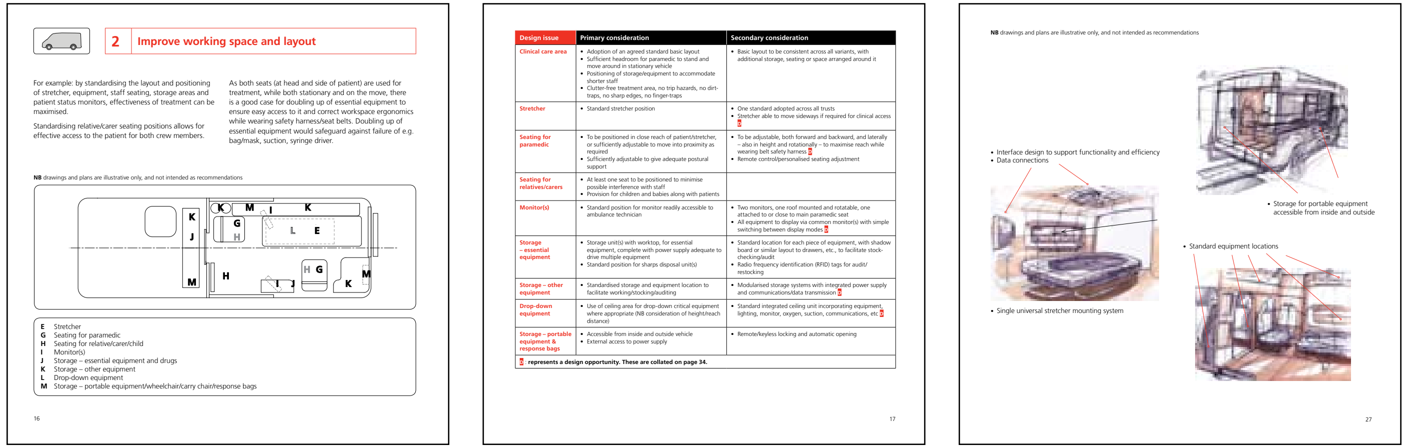


Figure 5
Front cover and three pages from one of two NPSA Future Ambulances project publications. The authors and project team included Prof Roger Coleman, Dr Sue Hignett, Prof Dale Harrow, Owen Evans, Merih Kunur, Sally Halls, Daniel Kafka, Emma Crumpton and Anna Jones. The two books were first published in 2007 by NPSA, London.



Developing a design direction
The two joint NPSA and Helen Hamlyn Trust reports established a range of safety criteria for the purchasing of ambulances, which underpinned moves towards standardisation within UK fleets (Harrow et al, 2008a).

A 'design direction' is a fundamental tool for strategic planning, acknowledging current issues and mapping out future directions and goals for an organisation. The following three-stage design direction was established:

1) Standardise over the next five years to meet current operational and design challenges, establish an efficient, integrated, national fleet, and ensure equipment reliability and compatibility.

2) Modularise within the next 10 years to consolidate service improvements and give the flexibility and adaptability in vehicles needed to deliver a wider range of healthcare and associated services within the community

3) Innovate to meet the evolving demands on NHS ambulance services.

Design challenges
Nine design challenges were identified and provide a sound basis for future vehicle development:

1) Ensure safe and effective access and egress
2) Improve working space and layout
3) Effectively secure people and equipment in transit
4) Ensure effective communication
5) Address security, violence and aggression
6) Facilitate effective hygiene and infection control
7) Maximise equipment usability and compatibility
8) Improve vehicle engineering
9) Humanise the patient experience

The nine design challenges reflect the current experience and working environment of ambulance personnel and the traditional, dual-crewed ambulance model.

However, many of the nine are relevant to other vehicles, and there are important cross-cutting issues such as communication, hygiene, standardisation of equipment dimensions, racking/storage systems and universal locking/attachment systems. Consequently, they should be taken into consideration across the full range of vehicles.

Performance requirements
Validated by an exhibition and questionnaire at Ambex 2006, the design challenges were translated into performance requirements, refined by vehicle designers at the RCA. Each performance requirement was divided into primary and secondary considerations to inform the current and future design of vehicles and equipment.

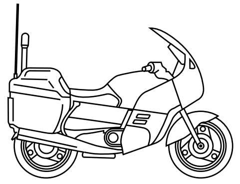
Primary considerations outline what should be happening now, whereas secondary considerations inform future design and innovation. Unlike a specification, performance requirements are not prescriptive and so should encourage innovation. For consistency, each performance requirement was mapped against a single vehicle type (Renault UVG Premia) and demonstrated with diagrams and supporting text.

The performance requirements draw attention to best practice, and were intended to generate discussion and agreement within the ambulance service.

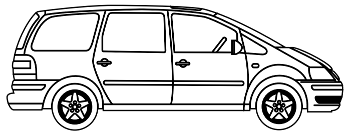
Visit www.npsa.nhs.uk for more information.

Typology of Ambulance Vehicles

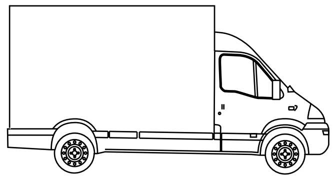
Bicycle
Used mainly within inner city areas, bicycles are a very rapid and convenient means for attending local incidents and emergencies. However, there is limited kit capacity and the rider has to be reasonably fit. Bicycles are not widely deployed by UK ambulance services.



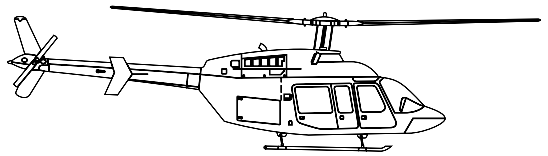
Motorcycle
This is the fastest means of transport within city environments. They are expensive to operate, because each rider has their own bike, helmet and protective clothing to ensure the highest levels of safety. Nevertheless, motorbikes are considered high risk response vehicles, and have limited kit capacity. They are now rarely used.



Estate car, sports utility vehicle (SUV) and multi-purpose vehicle (MPV)
These vehicles have become more popular with ambulance services in recent years, because they are relatively less expensive to operate and faster than van-type vehicles. They are relatively versatile and are frequently used for rapid response and ECPs.



Van
Conventional dual-crewed ambulances are modified vans (conversions) or van cab and chassis with a modular body. The conversions are less expensive, but tend to have a smaller treatment space. There are a wide variety of these on the UK market.



Helicopter
Helicopters are run by charities, set up to work alongside ambulance services. They are crewed by paramedics and sometimes doctors with additional skills and equipment. Helicopters are expensive to operate and tend to be reserved for the most serious incidents.

A Day In The Life Of...

Summary

The 'Day in the Life of' technique was employed as a means of looking at the role of an ambulance crew. This generic tool provides a graphic illustration of how time in the life of a specific role-holder is assigned to various activities. The tool highlights how available time is apportioned and can also be used to show how effectively the role-holder feels this time is being employed. As such is it is suitable for analysing workload prior to a wide-ranging change initiative. The tool employed here focused on 'as is' – the current reality. The tool can be expanded to look and compare the 'as is' situation to the 'should be' and 'could be' as a means of considering a range of alternative options.

From the workload analysis the majority of time is employed during the turnaround at the hospital, which is where the crew hand over the patient to the hospital. At this point the crew may consider restocking the vehicle. There is no specific amount of time projected, or set aside, for restocking.

At the start of the shift, the crew check the vehicle and its stock. However, if a 999 call came in, the crew would respond and the stock may be checked later. Currently, a process called 'make-ready' is being rolled-out, where, at bigger stations, a team checks and pre-prepares vehicles.

Looking at the workload for a city-based station, a crew responding to the average of 11 callouts, each of an average cycle time of 63 minutes, would end up working one hour and 27 minutes of overtime. According to the interviews, around 50% of 12 hour shifts show exactly this level of overtime.

A further interesting point was the activation time. At a station this could take up to 90 seconds from the time of receiving the call to leaving the station. At a standby point this could be around five seconds as the crew are in the ambulance and ready to go. However, if one looks at the workload analysis for the day the total time for activation is 16.5 minutes at a city station and 12 minutes at a rural station.

What is not clear from the analysis is how much time is spent on standby and where this is spent. It was evident that crews do spend some time on standby, but, particularly for city-based crews, this is rarely undertaken at the station.

Based on the interviews, the workload was broken down into the following activities:

1) Vehicle check
2) Activation
3) Drive to scene
4) Time at scene
5) Drive to hospital
6) Turnaround
7) Time at station/breaks

1) Vehicle check

The crew commence their shift. Generally they immediately respond to a callout, but in principle they start by checking their vehicle, making sure it is clean and fuelled with all the required equipment on board. Checks also ensure that the correct drugs are present. Drugs are signed for by the paramedic. There is no time set aside for this activity, and it is dependent on whether the crew are called out, as highlighted by one of the interviewees:

> *... there is no set time for doing that in terms of its projected time. If it is two minutes past eight and the shift starts at eight and a 999 call came in, they would go and hopefully check it later.*

2) Activation

Activation is the time from the call being passed to the crew and the crew being mobile. When the crews are station-based the activation time tends to be longer than when the crews are positioned at a designated standby point. At a station it can take up to 90 seconds to activate a crew compared to five to six seconds at a standby point. At a station the crew may be involved in cleaning the vehicle and, on leaving, need to ensure that the station is secure; at night the crew may be tired and may take longer to make ready. At a standby point the crew can simply move on from their position, as this interview extract demonstrates:

> *What you tend to find is that if they are on the station until the night when people naturally are more tired and tend to do some dozing in chairs. It can take 90 seconds to activate or you just throw a standby point and switch the key on and they are awake and it is five or six seconds compared to anything up to 90 seconds at night and at the times of the day. Because you will get distracted cleaning vehicles and then they got to shut all the doors to make sure the station is locked up, and make sure the windows are locked up. Whereas, if you already gone out to standby, you have not to do that.*

At East Midlands Ambulance Service (EMAS), each dispatch area has around 10 standby points, which are prioritised; EMAS tries to ensure that the highest priority points are always attended. The standby points have already been risk assessed and can range from a health service facility or centre to a local filling station. However, many sites that may be suitable as standby sites are not keen to have an ambulance parked outside, and there are some sites that crews are not keen to be based at, as highlighted by one of the interviewees:

> *A lot of places though are not very keen to have an ambulance parked outside. We have had experience where we have permission for things like little chefs and things like that but there can be a perception that there was some report of food poisoning at Little Chef because the ambulance was always there. Likewise, we use a lot of 24-hour petrol stations but they are not the best... There is always this supposed risk of causing a fire at a petrol station although there is no real evidence that she has start, I mean with mobile phones. But it is something that could play on crew's mind so we try to find some way that is mutually agreeable within a given area.*

3) Drive to the scene

This is the time taken by the crew to drive from the station or standby point to the scene. The time taken depends on the category of the call. The average time taken tends to be ten to 20 minutes. For a high priority call, the crew has eight minutes to arrive at the scene. For a non-urgent call it may take up to twenty minutes to arrive.

In the past, fast response vehicles and an ambulance crew would be sent to the same incident. Now, except for certain categories of call such as cardiac arrest, chest pain or road traffic accident (RTA), an emergency care practitioner (ECP) or a community practitioner (CP) is sent to assess the patient and then call for the appropriate vehicle or treat the patient at the scene. It is envisaged that in the future, there will be greater reliance on ECPs or CPs as opposed to double-crewed crews:

The double-man crew would not be used as much in the future as it is always the first person to hit the scene. It will often be the community paramedic or ECP who then decide what has happened and the back up they need.

4) Time at scene
This is the time taken assessing and treating the patient at the scene. The time spent at the scene can vary tremendously and is highly dependent on the qualifications of the crew.

An ECP or a CP may spend up to 45 minutes. An ECP or CP can make clinical decisions to determine whether the patient needs to go to an emergency department or whether an alternative care pathway may be pursued. Technician based crews tend to "scoop and run" – make a quick assessment of the patient on the vehicle, load and go.

However, there is a move within EMAS towards employing more ECPs:

Now, really we are trying to get away from that [the scoop and run approach] by deploying more ECPs and CPs who assess the patient on scene. Make it a clinical decision to say does he need to go to an emergency department. No. Can we go down to some alternate care? Can we treat it at home? Can we just leave at home and refer to GP in the morning? So, it is changing.

5) Drive to hospital
This is the time taken to drive the patient from the scene to the hospital. This can vary significantly. Some stations will have much greater job cycle times. Further, it depends on whether the crew are urban or rural based:

It ranges but it averages out and some of the rural stations have quite a lot higher job cycle times because they can spend 45 minutes driving from the patient to the hospital whereas in the cities it can be a lot quicker.

6) Turnaround
The turnaround is the period from arrival at the hospital, hand over of the patient and clear (the ambulance leaving the hospital). This stage shows a great deal of variability. The average turnaround time for EMAS is 21.5 minutes. However in North Derbyshire the average turnaround time is just over 15 minutes, but there are still stations that have an average turnaround time of nearly 30 minutes. It also varies from station to station, particularly between exit and roll over stations. Most roller stations are quicker at turnaround than the exit stations even though they can go to the same acute hospital. Efforts are being made by EMAS to reduce the turnaround time:

We have already brought it down from 28 and 29 minutes of the target. The target now is getting below 20 from 21 and a half on average and to set that nationally for arrival time for less than 15. Virtually on acute now, it is less than 15, most is down to less than 10. It is just a couple now that the ones that are dong 12 and 14.

7) Time at station/breaks
The time a crew spends at stations and on breaks is clearly dependent on how busy their shift is. For a city station, crews on a 12 hour shift can expect to respond to, on average, 11 calls. Within an average cycle time, this does not allow the crew any time for breaks, or time at the station. For a rural station, a crew may expect to respond to an average of eight calls, which would allow time for breaks or station stops. EMAS tries to ensure that the crews have time for meal breaks but on a busy day the crew may be out for the whole shift. EMAS does have to allow for a significant amount of incidental overtime:

We do have to allow of quite a lot of incidental overtime at the end of the shift. So, anything from 15 minutes to two hours is not unusual. I would guess on average probably we got three or four 12-hour shifts, one or two of those they will be late finishing.

What became apparent during the interviews was the lack of time spent on returning to the station to restock the vehicle. On average a crew may return to station twice during a shift stocking up on consumables, they may also stock up at hospitals where in some cases there may be cages or cupboards containing stock. These are placed at strategic locations such as emergency departments and pilots have been carried out where a make-ready individual has been sited at hospital to restock the vehicle whilst the crew are handing over the patient. However, it was highlighted that, in general, the vehicles tended to be overstocked and there is little need for crews to stop regularly to top up their equipment:

...the vehicles really carry enough of the resources. Certainly for drugs, they could go to two cardiac arrests one after the other and they have got enough drugs for that and then have to go back to station to restock. They pretty much carry enough oxygen although crews like to play safe with oxygen. They pretty much carry enough oxygen to last a week in massive big cylinders. ... but really there is so much gas on the vehicles and if we were to go and do the spot check up there now and look how many consumables or like how many oxygen masks, you would probably find 30 oxygen masks on the vehicle. Completely outrageous, but in a way that is the culture and nature of the field - that they got plenty of it!

This was reinforced by another interviewee who agreed that ambulance crews have always tended to overstock their vehicles, which can have negative consequences:

I think it is an ambulance man or ambulance woman thinking what you tend to put much of everything they can get on a toll. If there is a space, they will fill it which is not always good if it is overloaded with stuff. It affects the miles of a gallon, affects the handling, nothing serious, but if you have, for example, too many officers and some of them are on the vehicle. It kind of has a detrimental effect because you cannot secure them all. So you could have them flying around and that would be problematic.

A Day In The Life Of...

Bicycle Paramedic

Sample day 1

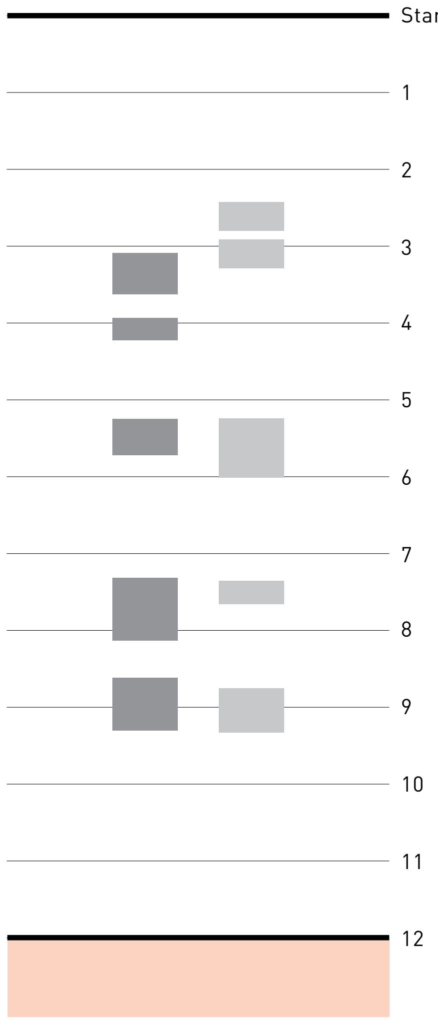
Sample day 2

Locations

10 km

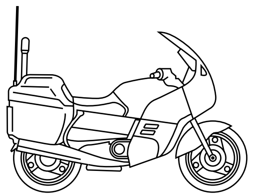
Figure 6, above
Geographic distribution of calls and ambulance attendence. Bicycle stationed in City A.

Figure 7, right
Job cycle times from two sample 12 hour shifts.



A Day In The Life Of...

Motorcycle Paramedic



Sample day 1

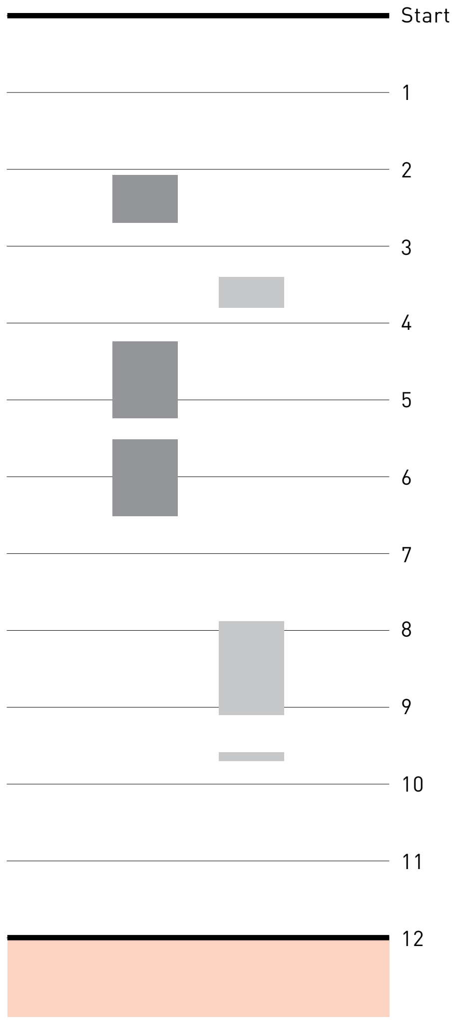
Sample day 2

Locations

10 km

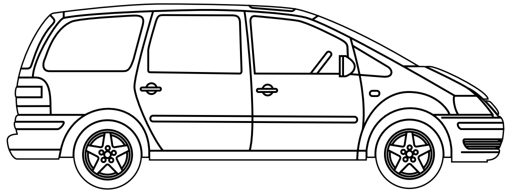
Figure 8, above
Geographic distribution of calls and ambulance attendence. Motorcycle stationed in City A.

Figure 9, right
Job cycle times from two sample 12 hour shifts.



A Day In The Life Of...

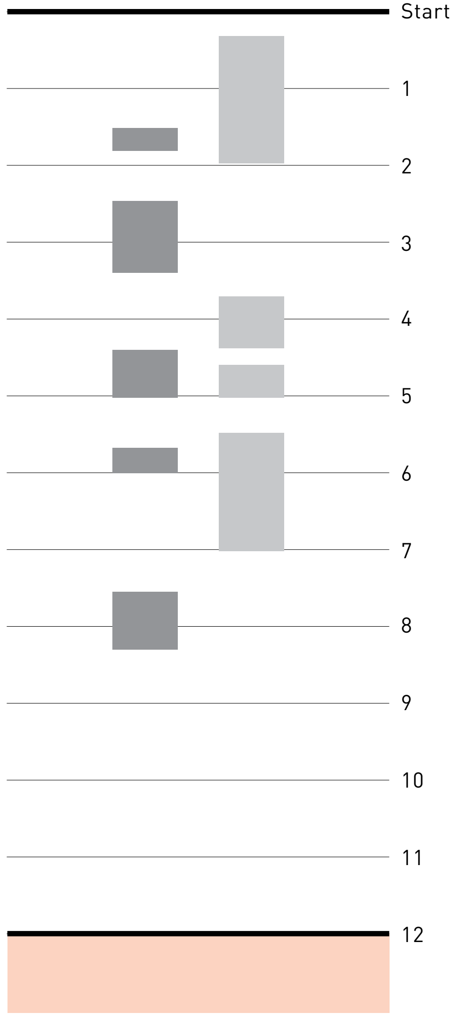
ECP in Provincial City



Sample day 1
Sample day 2
Locations
10 km

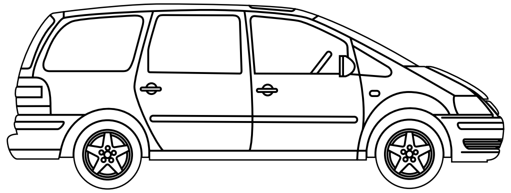
Figure 10, above
Geographic distribution of calls and ambulance attendence. ECP stationed in City A.

Figure 11, right
Job cycle times from two sample 12 hour shifts.



A Day In The Life Of...

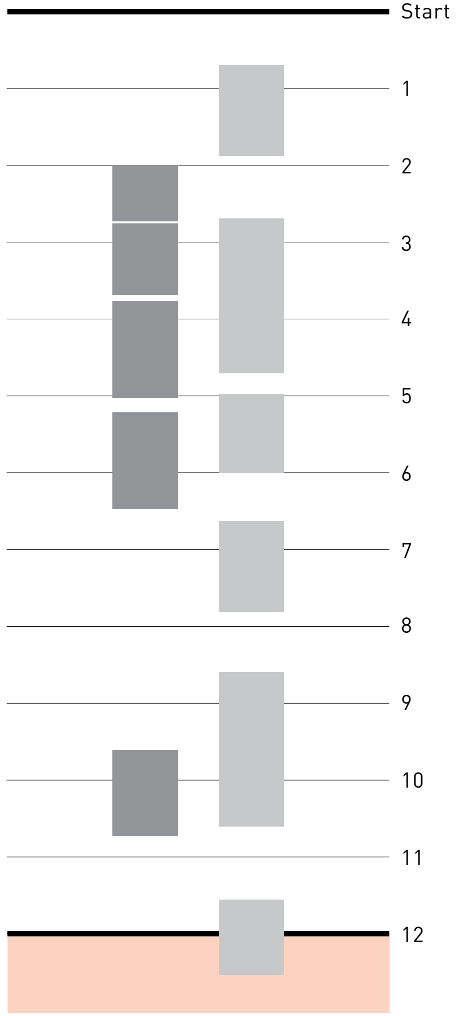
ECP in Major City



Sample day 1
Sample day 2
Locations
10 km

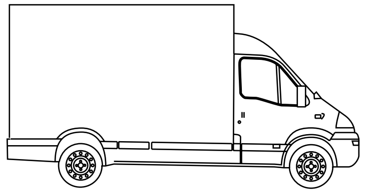
Figure 6, above
Geographic distribution of calls and ambulance attendence. ECP stationed in town, outside of City B.

Figure 7, right
Job cycle times from two sample 12 hour shifts.



A Day In The Life Of...

Dual Crewed Ambulance



Sample day 1

Sample day 2

Locations

10 km

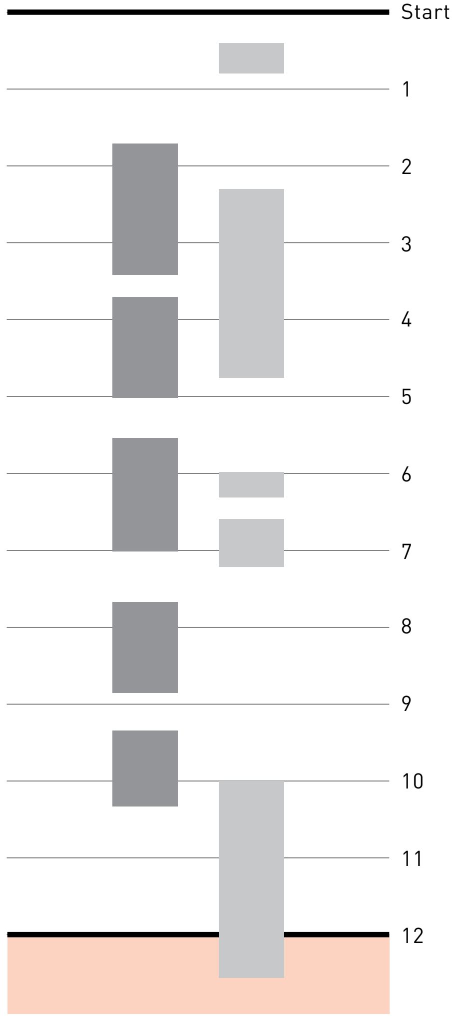
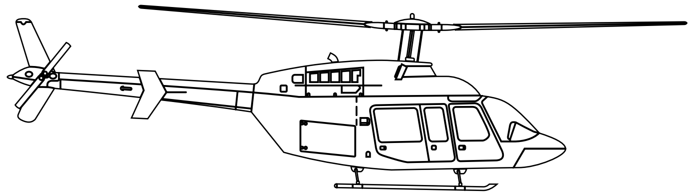


Figure 14, above
Geographic distribution of calls and ambulance attendence. Dual-crewed ambulance based at station away from City A.

Figure 15, right
Job cycle times from two sample 12 hour shifts.

A Day In The Life Of...

Air Ambulance



Sample day 1

Sample day 2

Locations

10 km

Figure 16, above
Geographic distribution of calls and ambulance attendence. Helicopter based at station away from City A.

Figure 17, right
Job cycle times from two sample 12 hour shifts.

Overview of Ambulance Vehicles

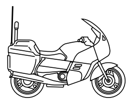
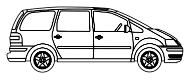
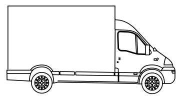
	BICYCLE	MOTORCYCLE	ESTATE, SUV AND MPV	VAN	HELICOPTER
					
IN OPERATION	>100	>100	<2,000	<2,500	30
TOTAL COST	£2,000–5,000	£16,000–20,000	£25,000–40,000	£110,000–160,000	£4,500,000
LIFE EXPECTANCY	5–10 years	years miles	7 years 100,000 miles	7 years 100,000 miles	10 years
MAINTENANCE COST	£500/annum Serviced around 1.5 times per annum	£6,500/annum Serviced every 10,000 miles or 10 weeks	£4,500/annum Serviced every 8,000 miles or 8 weeks	£6,500/annum Serviced every 10,000 miles or 10 weeks	£230,000/annum Serviced every 400 and 800 hours
FUEL ECONOMY	-	42.5 mpg	30–40 mpg	32 mpg	200 kg/hour
STORAGE	0.08 m3	1.0 m3	1.6–1.9 m3	11 m3	3.8 m3
FOOTPRINT	0.6 x 1.7 m	0.9 x 2.3 m	1.9 x 4.4–4.8 m	2.0 x 5.6 m	12.5 x 2.6 m
LICENCE REQUIREMENTS	**Emergency Services Cyclist Training Course** A high level of fitness is required.	**Category A** Motorcycles up to 25kW (33bhp) and a power to weight ratio not exceeding 0.16kW/kg (minimum age 17). Expensive additional training required.	**Category B** Motor vehicles with a MAM not exceeding 3500kg having not more than eight passenger seats with a trailer up to 750kg (minimum age 17)	**Category C** Vehicles over 3500kg (minimum age 21)	**Pilot** Helicopter pilot licence with instrument rating and night rating

Table 5
Ambulance service vehicle typology

Improving the Existing Ambulance

Whilst new vehicle architectures developed to take healthcare to the patient will contribute towards a totally new system for treating patients outside emergency departments, it is understood that there will still be a need for a conventional dual-crewed emergency ambulance (DCA) (see Design Platforms and Traffic Light Model, page 51 and page 56).

The current DCAs, for all their wide variety, are clearly not ideal for the roles for which they are commissioned (see Summary, page 1). A range of basic shortcomings were identified by a design decision group, held at the Royal College of Art, London, with experts in vehicle design and engineering. The results are listed in table 6, below, with potential design interventions that could bring about genuine improvements, such as enhancing patient safety, improving ride quality and handling, and reducing maintenance costs whilst extending the life of this type of vehicle.

DYNAMIC SHORTCOMINGS	POTENTIAL DESIGN INTERVENTIONS	OPERATIONAL SHORTCOMINGS	POTENTIAL DESIGN INTERVENTIONS
Poor ride quality	• Air assisted self levelling suspension • Reduced un-sprung weight • Up-rated brakes • Variable rate dampers	**Often used close to chassis weight limits**	• Weight reduction through lightweight construction • Kit optimisation
Poor handling qualities	• Lowered centre of gravity • Reduced weight • Optimised weight distribution • Electronic traction intervention • Reduction in side wind sensitivity	**Hard to load some stretcher cases**	• Variable-height suspension • Optimised stretcher • Improved manouverability • Flat vehicle floor
Excessive fuel consmption	• Aerodynamic 'drag reduction' • Weight reduction • Reduced frontal area	**Expensive to procure**	• Standardisation of vehicle and kit • Design for purpose not a conversion or box construction
Limited performance	• Weight reduction • Reduction in aerodynamic drag • ECU controlled automatic transmission system	**Limited operational lifespan**	• Analysis and optimisation of failing parts

Table 6
An overview of the exisitng dual-crewed ambulance's shortcomings and potential design interventions.

The Hardware Design Challenge

The hardware design challenge is complex and relies on the resolution of three key elements: portable treatment packages (see page 83); treatment space (see page 71); and the vehicle for delivering a treatment capability. Ease of redeployment is an important consideration.

1) How can clinical and vehicle design and engineering requirements be optimally combined in a mobile treatment space?

The clinical functionality and safety for patients is at the forefront of this design research programme. Design issues relating to patient safety and clinical functionality were extensively explored in the NPSA Future Ambulance Project (page 33). Further work has been carried out at Loughborough University to specify the design requirements for a mobile treatment space (page 71).

The vehicle package will be defined by an analysis of vehicle dynamics and performance requirements using integrated system modelling to simulate the duty cycle, e.g. required range, acceleration, braking and cornering performance, proposed unladen mass, payload, and the anticipated dimensions of the vehicle. Testing and evaluation of a range of treatment space packages, put forward by the research team, defined by dimensions and evaluated by clinicians and patients, will identify the optimum clinical and vehicle package.

2) To what extent can the treatment space be packaged and mobilised for care in the home?

Standardisation and modularisation are key to packaging the equipment and consumables is such a way that they can be mobilised and taken into a patient's home quickly and efficiently. Kit lists have been identified through design decision groups with clincians (see Portable Treatment Packages, page 83). Once resolved, these lists will provide a basis upon which sound design propositions can be put forward.

3) Is there an opportunity for a vehicle powered from sustainable sources?

There is clearly a need to investigate sustainable alternative or combination vehicle power sources for future vehicles (NHS, date unknown). There are three main areas of development: electric, hydrogen fuel-cell and hybrid (a combination of electric or hydrogen fuel-cell and a conventional internal combustion engine). The drivers for adoption include a reduction in harmful emissions, reduced maintenance and running costs, and improved operational lifespan. A common factor which will positively influence all of these drivers is reducing the mass (a function of overall size, materials selection and design strategy) and aerodynamic/rolling resistance (again, linked to size, mass and design).

There are many examples of commercial electric vehicle applications, such as Tesco's zero-emissions delivery fleet (page 65). A small number of Mercedes-Benz Citaro public buses used in UK, Germany and the Netherlands, have been converted to hydrogen fuel-cells.

4) What are the future enabling technological opportunities that will support clinicians and patients outside hospital?

Better navigation to scene can be achieved through satellite and inertial navigation, supplemented by mobile phone positioning. Ambulance call operators can use databases containing the exact location of landline phones (Flat C, third floor…). Use of digital communications will enable remote assistance and compensate for not being in a hospital with resources (people, equipment, expertise). Improved capability will be enhanced by video data link to specialist practitioners and diagnostic expertise. Patient-specific NHS cards could be used to accelerate diagnosis through access to medical records. More vulnerable patients would be instantly flagged through this process. Following treatment, patient safety can be maintained through the adoption of 'Assisted-Living' patient monitoring resources.

5) What is the optimum vehicle platform to deliver clinical capabilities outside hospital?

The size and mass of dual-crewed ambulances has been steadily increasing in response to the wish to increase capability and the amount of equipment carried. In the future, a rise in congestion, fuel prices and increased demands on the Ambulance Service will make it attractive to reduce the size and weight of the vehicle. By contrast, future enabling technologies, such as portable diagnostics and life saving equipment, is likely to increase the required size of an ECP, or other, urgent vehicle. These two opposing sets of driving forces will bring the optimum size for urgent and emergency vehicles closer together (see figure 18 below).

The benefits of a standard vehicle platform include that it is pre-designed and fit for purpose. This means there are common maintenance issues, reduced maintenance costs and improved economies of scale.

Mobilised services in the NHS that could benefit from the development of an optimised vehicle platform include patient transport, immunisation programmes, community nursing, social services, GPs, ECPs, Paramedic Practitioners and major incidents.

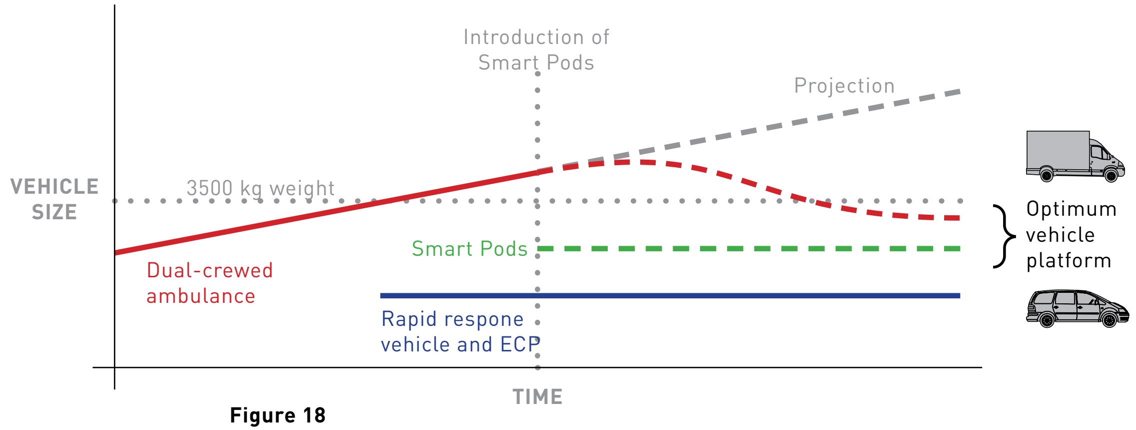


Figure 18
Identifying an optimum vehicle platform for urgent and emergency vehicles in the future.

Design Platforms

Four design platforms were developed as a result of analysis and synthesis of a diverse set of patient scenarios (see Mapping Patient Scenarios, page 23) within a multidiscipline design decision group:

1. Front-loaded: teams of first and second responders
2. Dual-crewed ambulance (DCA): based on conventional emergency ambulance model
3. Targeted treatment: matching treatment type and referral options to patient needs
4. Distributed healthcare: distributed treatment pods linked into the existing high street infrastructure.

Each platform is based on a multi-level system made up of a mix of skills, vehicles and equipment, and can be analysed according to the four key stages of service delivery: 999 call; response; mobility; treatment. They have been developed in parallel and, similar to military medical platforms (see Army: Military Medical Protocols, page 86). The final solution is likely to be an amalgam of two or all of them.

These platforms provide a basis upon which ideas can be challenged and validated. They faciliate decision-making, by contextualising design opportunities in a healthcare delivery system.

The effectiveness of each design platform was evaluated using Traffic Light modelling – a recognised management tool used comparatively, to evaluate ideas against a baseline of current practice. This can indicate the likely trade-offs and limitations, potential improvements in performance of each, and identify their strengths and weaknesses. A conventional DCA was established as the benchmark (platform 2 emergency scenario, page 53), against which the other platforms were compared in terms of cost, time and quality.

A clear distinction emerged between the provision of urgent and emergency care in the different design platforms. For example, sending a conventional DCA to urgent patients has limited benefits, whereas platform 3, based on the ECP model, performs very well in urgent scenarios. This is because the level of dispatch is proportionate to the patient's requirements. However, the same platform is not so suitable for emergency calls. This is mainly due to a need for rapid conveyance to ED and a suitable number of staff to assist the patient.

KEY

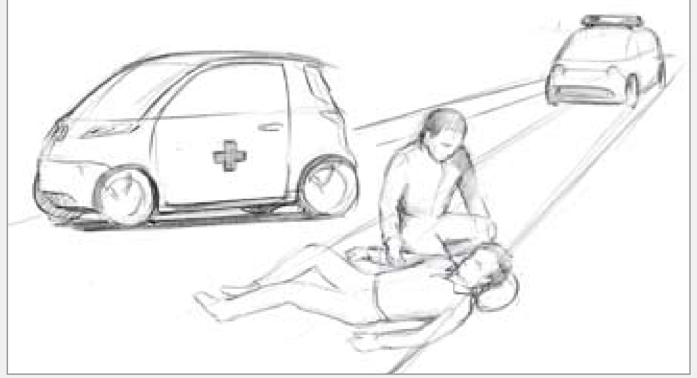
- A First responder
- B Second responder
- Patient scenarios
- 999 call
- Conventional dual-crewed ambulance (DCA)
- H Accident and emergency (A&E) department
- POD Stationary mobile treatment space
- Lines of communication
- Vehicle and/or patient journey

Design Platforms

1) Front Loaded

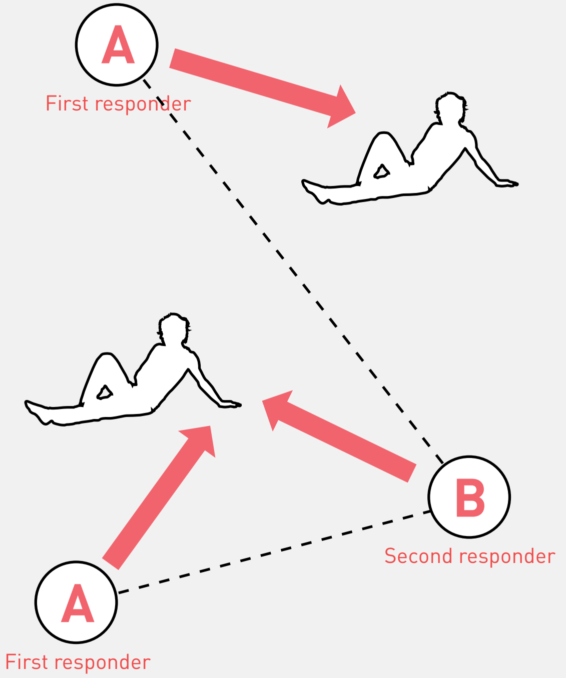
Teams of highly trained first responders in rapid and compact modes of transport (A), working autonomously and with advanced communication technologies. Each team is supported by a slower moving, treatment and conveyance module (second responder – B) and centralised specialist support. The secondary response is upgraded or stood-down as appropriate.

EMERGENCY SCENARIO



URGENT SCENARIO

SYSTEM OVERVIEW



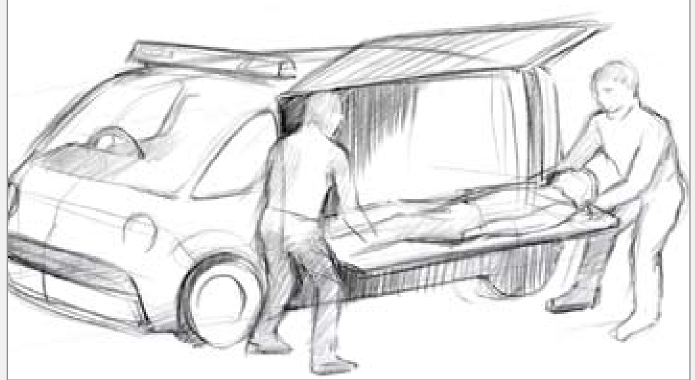
Design Platforms

2) Dual-Crewed Ambulance

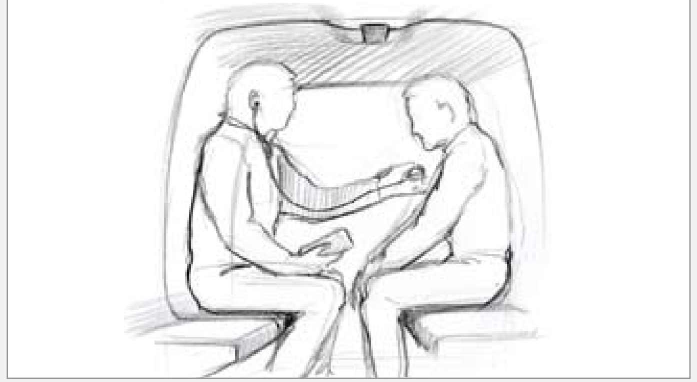
This is based on the conventional emergency ambulance model: dispatch a two-person team to assess, stabilise and convey the patient to ED for further treatment.

Teams are made up of a mix of skills that may include drivers, technicians and paramedics. This model is currently dispatched to all types of calls, including emergency and urgent, with the same mix of skills and equipment.

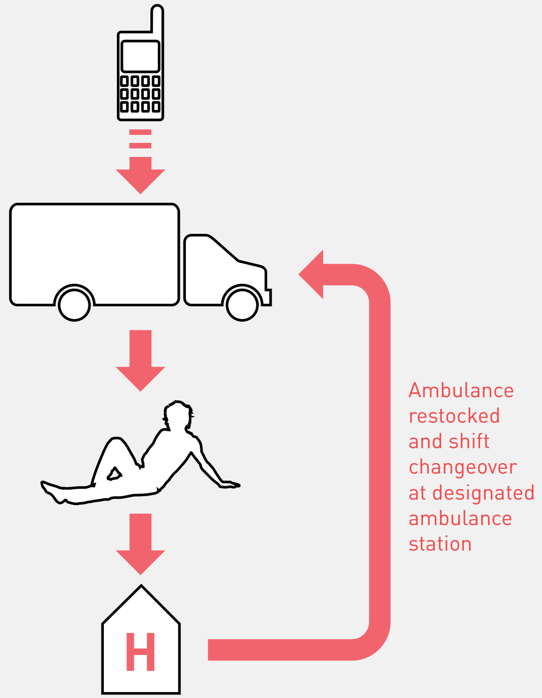
EMERGENCY SCENARIO



URGENT SCENARIO



SYSTEM OVERVIEW

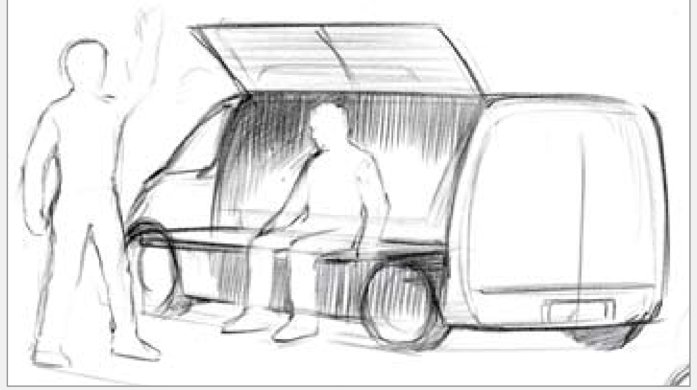


Design Platforms

3) Targeted Treatment

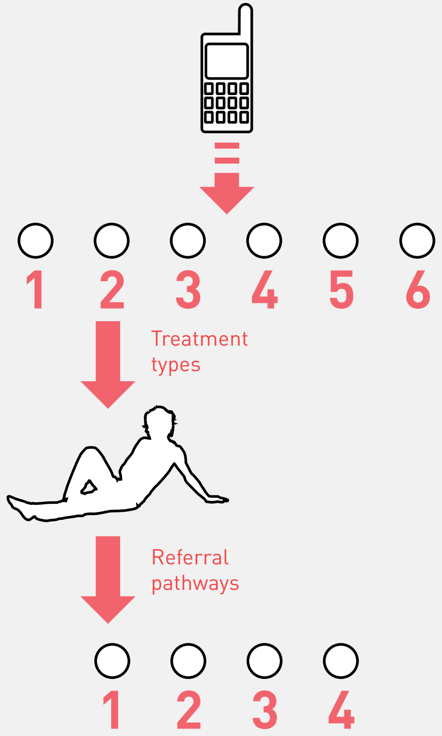
The dispatch process matches a treatment type to patient scenarios, which is determined over the telephone. Solo-crewed vehicles, based on the ECP and rapid response model, are despatched to the appropriate calls. There is an opportunity to include predictive treatment types (ie screening programmes, Friday night or football match), scheduled care (follow-up care or out-patient care) and unscheduled pre-hospital care (which would require diagnosis and triage over the phone before dispatch and include the provision of referral pathways).

EMERGENCY SCENARIO



URGENT SCENARIO

SYSTEM OVERVIEW

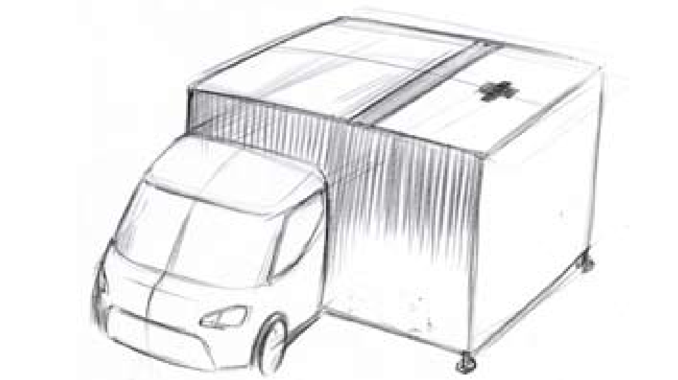


Design Platforms

4) Distributed Healthcare

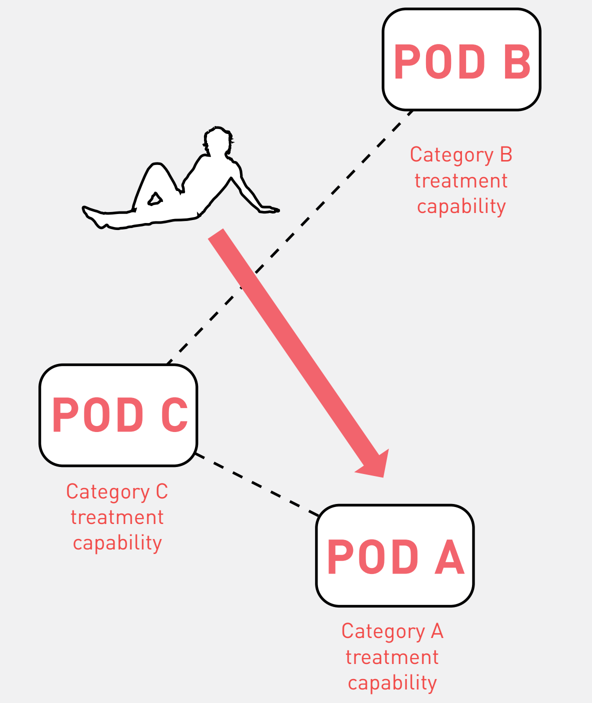
Configured to deliver preventative care as well as urgent and emergency care in the community, distributed healthcare is accessed by means of mobile treatment spaces, which are located according to need. In this case, patients make their own way to the treatment space, which is temporarily stationed in a community and supported by an existing high street infrastructure. The pods are equipped to diagnose and treat a wide range of conditions.

EMERGENCY SCENARIO



URGENT SCENARIO

SYSTEM OVERVIEW



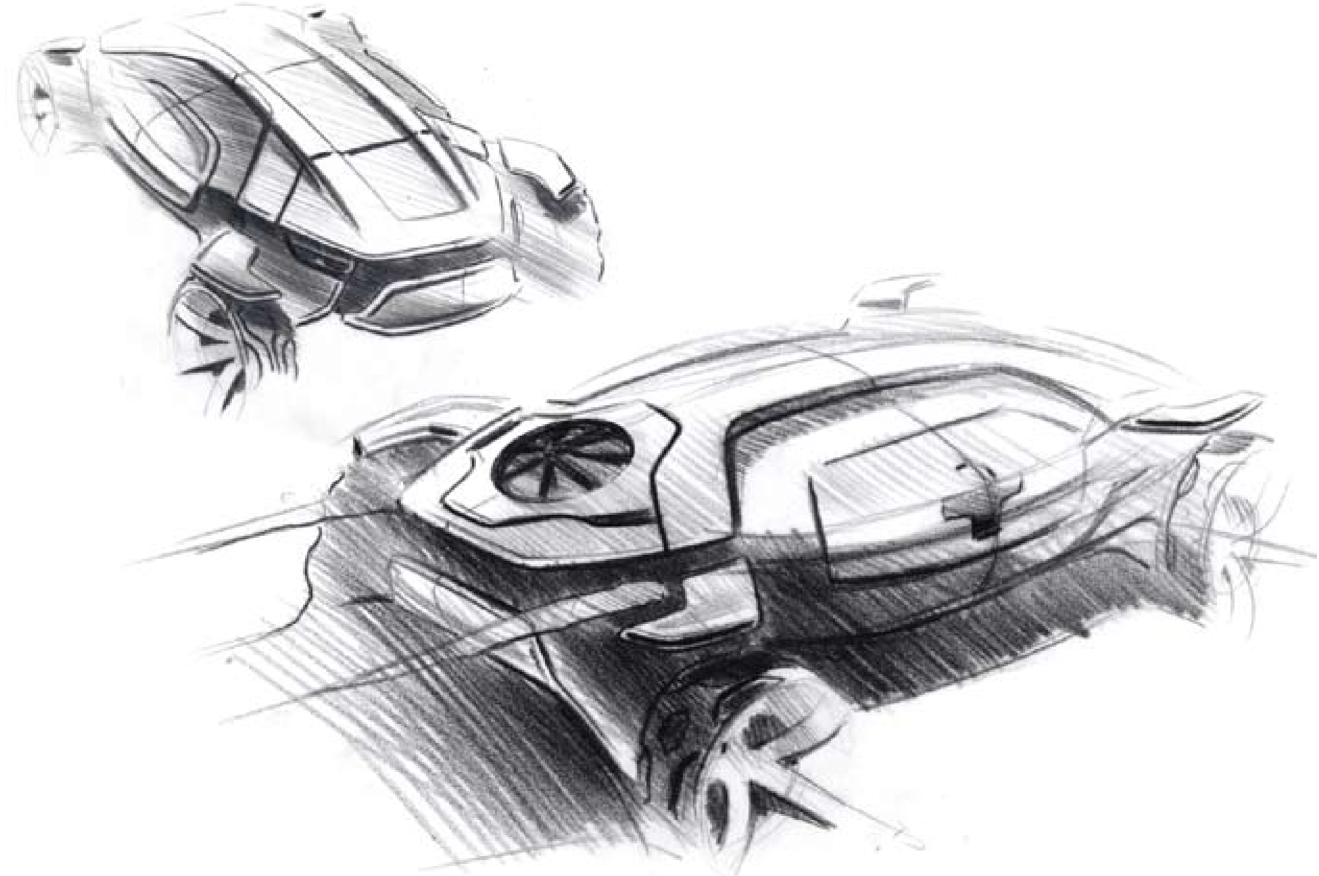
Traffic Light Model

	EMERGENCY – DESIGN PLATFORMS 1	2	3	4	URGENT – DESIGN PLATFORMS 1	2	3	4
Purchase of vehicles	Green	Amber	Green	Red	Green	Red	Green	Amber
Kitting out	Green	Amber	Green	Red	Green	Red	Green	Red
Vehicle running costs	Green	Amber	Green	Green	Green	Red	Green	Green
Salaries	Red	Amber	Red	Red	Green	Red	Green	Red
Replenishment costs	Green	Amber	Amber	Red	Green	Amber	Amber	Red
Fleet complexity	Red	Amber	Red	Red	Red	Amber	Red	Red
Change costs (eg training)	Red	Amber	Red	Red	Red	Green	Red	Red
Treatment capability (skills)	Green	Amber	Red	Green	Green	Amber	Green	Green
Treatment capability (kit)	Red	Amber	Red	Green	Amber	Amber	Green	Green
Mix of skills	Green	Amber	Red	Green	Red	Red	Green	Green
Patient expectation	Red	Amber	Red	Amber	Red	Amber	Red	Green
Patient experience	Green	Amber	Amber	Green	Green	Amber	Green	Green
Safety of the crew	Red	Amber	Red	Green	Red	Green	Red	Green
Crew satisfaction	Green	Amber	Red	Amber	Green	Red	Green	Amber
Swarming capacity	Amber	Amber	Amber	Amber	Amber	Amber	Amber	Amber
System scheduling capacity	Green	Amber	Green	Green	Green	Amber	Green	Green
Speed of first response	Green	Amber	Green	Amber	Green	Red	Amber	Amber
Speed of conveyance	Amber	Amber	Red	Amber	Red	Green	Red	Red
Time impact of stand downs	Green	Amber	Green	Green	Green	Amber	Green	Green
Impact on peak A&E times	Green	Amber	Green	Green	Green	Red	Green	Green

KEY

Better than	Green
Equal to	Amber
Worse than	Red

Royal College of Art Masters Vehicle Design Project



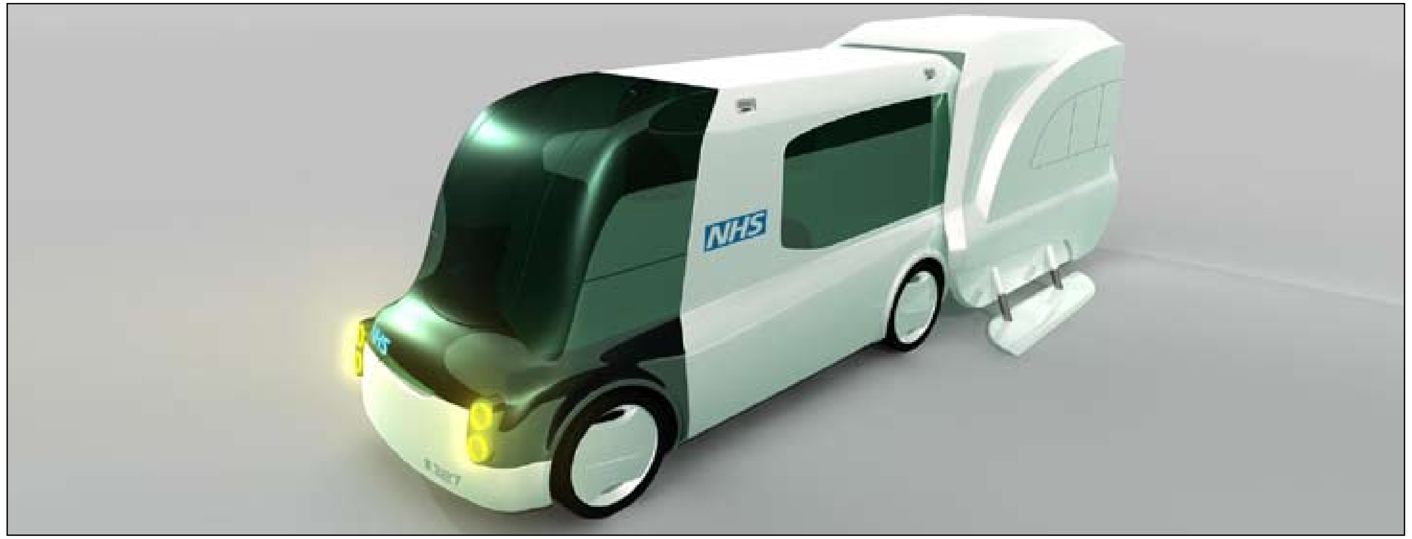
Initial findings from the Smart Pods project were presented to Masters students on the Royal College of Art Vehicle Design course. With input from clinical and design experts they produced a range of original and innovative design solutions, including vehicles geared towards taking healthcare to the community.

Design propositions range from multi-purpose and off-road vehicles to large, slower moving treatment units, designed to deliver a slice of the emergency department in the heart of the community.

These projects are radical: they are a direct response to the Smart Pods data and provide an insight into what urgent and emergency vehicles of the future might look like.

Royal College of Art Masters Vehicle Design Project

Shell Concept



Designer
Rui Guo

Concept
Shell Concept

Year
2009

Dimensions
Length: 4.4 m (6.2 m when expanded)
Width: 1.7 m
Height: 1.9 m

Brief Description
In the future, urgent response vehicles will not be required to travel at high speeds. The look and feel of such vehicles will reflect a new type of service, which is geared to treating people at home, rather than taking them to hospital at speed.

The Shell Concept is a compact and efficient vehicle designed for the delivery of urgent medical capability. The removable 'shell' can be deployed to create an expanded treatment space, or left on-scene for extended periods of time. It is equipped with all the kit and consumables required.

To accommodate a range of uses the shell is interchangeable: multiple treatment units can be prepared at base ready for immediate deployment.

Royal College of Art Masters Vehicle Design Project

Morphing Interior Concept

Designer
Miika Heikkinen

Concept
Morphing Interior Concept

Year
2009

Dimensions
Length: 4.2 m
Width: 2.2 m
Height: 1.9 m

Brief description
Every time a clinician attends a 999 call, the situation and condition of the patient is different: no two calls are alike. To overcome this problem and create a safe and effective treatment space, this concept has a revolutionary interior, which morphs into shape. The form is takes is determined by the type of patient and subsequently the treatment they need.

The soft silicone interior is combined with cutting-edge technologies, including flexible and ultra-thin wall mounted displays and portable video.

Portable treatment packages can be accessed from inside and outside the vehicle and treatment space. This enables trained medical staff to work quickly and efficiently, for example, in a patient's home.

Royal College of Art Masters Vehicle Design Project

Mobile Treatment Concept

Designer
Niki Merriman

Concept
Mobile Treatment Concept

Year
2009

Dimensions
Length: 5.0 m
Width: 2.0 m (3.4 m when expanded)
Height: 2.3 m

Brief description
Mobile treatment solutions are in some cases restricted by their medical capability (the quanitity of kit and mix of skills that can fit on-board). The Mobile Treatment Concept is large enough to deliver a slice of the hospital to remote and isolated communities.

The vehicle is a similar width to current ambulances and pivots in the middle to enable it to navigate urban and rural environments. On-scene, the body of the vehicle expands by almost a metre each side, which creates a large and capable treatment space inside.

This vehicle concept has potential to be used for delivering urgent and planned care, as well as social services and treatment programmes into the community and away from hospital.

Royal College of Art Masters Vehicle Design Project

Ladybird Concept

Designer
David Seesing

Concept
Ladybird Concept

Year
2009

Dimensions
Length: 3.0 m (5.5 m when expanded)
Width: 1.3 m (4.5 m when expanded)
Height: 1.7 m (2.3 m when expanded)

Brief description
This agile concept deploys a temporary treatment space on-scene to enable pre-hospital clinicians to carry out time-consuming and complex treatments in the community. The rigid canopy structure protects the clinician, patient, equipment and consumables from the elements, even in the most extreme environments.

The Nomad Concept is capable of driving off-road and is narrow, making it suitable for delivering care in all types of environments, such as isolated rural areas, national parks, and congested and restricted urban locations.

The deployable tent is based on the Hoberman principal: it can be packaged very small and expands into a rigid dome structure instantly when deployed.

Royal College of Art Masters Vehicle Design Project

Cocoon Concept

Designer
Dalibor Pantucek

Concept
Cocoon Concept

Year
2009

Dimensions
Length: 4.7 m
Width: 2.7 m
Height: 1.9 m

Brief description
The Cocoon Concept is modular: it is possible to adapt the configuration of the treatment space and storage capacity. This is achieved by interchanging two side 'pods' to suit the role of the vehicle.

It is possible to customise the Cocoon during production and on base, prior to dispatch. Therefore, this concept is suitable for on- and off-road applications in remote, rural and urban settings.

Pods can be designed to suit all types of urgent and emergency requirement, such as conveying to an emergency department, a treatment space, additional carrying capacity for people sitting, or lying, and additional kit and storage space. The Cocoon Concept is a unique solution for demanding environments.

Royal College of Art Masters Vehicle Design Project

Autocare Concept

Designer
Augustin Barbot

Concept
Autocare Concept

Year
2009

Dimensions
Length: 4.2 m
Width: 2.2 m
Height: 1.6 m

Brief description
Speed is of the essence in the ambulance service. The Autocare Concept aims to get the pre-hospital clinician on-scene and ready to treat the patient as quickly as possible.

The design includes an ejector-type driving seat for a single clinician. The seat is activated once the vehicle is on-scene and projects the driver outside the vehicle. The seat is equipped with all the treatment packages required for the patient and deploys as a backpack with the clincian.

Autocare Concept is capable of driving off-road. The vehicle width expands to accommodate rugged off-road conditions. Speedy patient loading is made possible by access through the back of the vehicle.

Case Study

Tesco: Zero Emissions Delivery Fleet

Tesco has demonstrated how a vehicle-based service can have a dramatically reduced carbon footprint by using zero emissions vehicles. Key learnings include: developing and launching new vehicle architectures.

Introduction
Along with a range of carbon reducing initiatives, Tesco home delivery service launched a pilot fleet of 15 zero emission delivery vans at their eco store in Shrewsbury, in April 2007. Following the success of the pilot scheme, Tesco has spread the zero emission fleet to cover London and Newtownbreda. Tesco is expected to launch more vehicles in Belfast, Birmingham and Glasgow in the near future.

Tesco was the first supermarket chain to launch a fleet of electric powered zero emission delivery vans. The vans were designed and built by Modec, UK, and production began in March 2007. Combined, Tesco and Modec make an exemplar case study in this fledgling market. Following the success of this pilot, many more companies have adopted these vehicles for urban delivery services, including M&S, Hildon, FedEx and UPS.

Tesco claims that each zero emissions van saves around 21 tonnes of carbon dioxide per year, which is equivalent to driving 51,000 miles in a conventional car powered by an internal combustion engine.

Range has been an issue for electric powered vehicles in the past. These vans are capable of 100 miles or 60 miles between charges, depending on the choice of battery. Each Modec has a top speed of 50mph and can carry up to two tonnes. The vehicles are designed to run through the day and be charged overnight, benefiting from reduced electricity costs.

Modec has won several awards for the vehicles, including the 'Editors' Choice Award for New Product Innovation' at Work Truck Show in Atlanta, 2008 and the GreenFleet 'Electric Vehicle of the Year, 2007'. In September 2008, Modec was featured in the Guardian Cleantech 100 list as one of Europe's leading clean technology companies (Guardian, 2008).

Reduced lifecycle costs
Electric powered vehicles benefit from considerable savings relating to road tax and operator license. They are exempt from the London Congestion Charge. They have minimal moving parts and components – three compared to around 300 in a conventional van diesel combustion engine – so service and maintenance costs are reduced.

Electricity costs equate to around 7 pence per mile. Overnight a full charge costs around £4 (Modec 2008) and takes roughly six hours. Therefore, these vehicles currently work out around £750–£1,000 more expensive to run each year in London than an equivalent diesel-powered delivery van (What Van, 2008).

Modec sells the vehicle and leases the battery. This ensures that the batteries are maintained by experts in this field, can be replaced when improved battery technology becomes available and are properly recycled at the end of their useful life. The cost of the battery lease depends on the mileage and duration of the lease.

The vehicles have a 375,000-mile or 12-year design life. The chassis, bodywork and components are designed for disassembly and recycling: 98% of the vehicle is recycled at the end of its useful life.

Battery technology
Modec has two battery technologies: Sodium Nickel Chloride and Lithium Iron Phosphate (LFP). Both types have a top speed limit of 50mph and achieve 0–30mph in 11 seconds. The electric motor develops 300Nm of torque, which is ample for urban traffic conditions.

The 'Zebra' Sodium Nickel Chloride batteries are manufactured by MEA-DES, Switzerland. They have an average range of 100 miles, are relatively safe and reliable, have a capacity of 85kWh and operate over a wide temperature range. The anticipated lifecycle in a car is ten years and up to 300,000 miles (Seattle Electric Vehicle Association, 2008). Zebra batteries are about 60% lighter than a lead acid equivalent.

The LFP batteries are less expensive, but the average range is only 60 miles. Unlike Zebra batteries, LFP batteries do not need to be left plugged into a power supply when not in use and have very slow loss of charge. Zebra batteries operate at a relatively high temperature and so if left unused or unplugged for more than a couple of days they will need to be plugged in and warmed up for a day or so before they are fully operational.

LFP batteries are unlike other batteries based on Lithium ion chemistry – such as Lithium Cobalt batteries that were introduced by Sony over 15 years ago and are commonly used in consumer electronics like mobile phones and laptops (Science News, 2002) – they have a slower capacity loss rate and higher power density. LFP batteries have larger cells and can be produced in larger sizes with reduced weight and increased stability and performance.

Vehicle platform development
The box van type vehicle (category B, see Typology of Ambulance Vehicles, page 36) weighs 5.5 tonnes (3.5 tonnes curbsideweight and 2 tonnes maximum payload) and measures 2m wide, 6m long and the roof of the cab is 2.6m high. The conventional box van has a capacity of 12 cubic metres and has standing headroom.

The current battery technology requires a limit of 50mph to ensure 100-mile range (for the Zebra battery). Regenerative braking has been incorporated to extend the range by returning power to the battery when braking or decelerating. The total range achieved varies with duty cycle. Better mileage is achieved when the vehicle is stopping and starting as opposed to sustained high speed.

The vehicles have been designed around the battery to make sure it is future-proofed: new battery technology can be incorporated into the existing chassis without significant investment. A flat floor has been achieved by fitting the battery into the ladder frame chassis.

New batteries are loaded into the chassis from underneath, which takes approximately 20 minutes, making it possible to run the vehicles 24 hours a day, seven days a week, should it be required.

4.
Treatment

Once admitted as an emergency, patients stay in hospital for an average of 6.8 days at a cost of around £7,000 to the NHS.

Treatment Overview

Taking treatment to the community
Recent years have seen a clear shift in healthcare policy towards the delivery of healthcare in community settings and close to the patient's home wherever possible. Increasing specialisation and centralisation of a small minority of rarer but important conditions (such as heart attack, stroke and major trauma) have been accompanied by moves towards community delivery for the vast majority of routine and urgent healthcare (Boyle, 2006). Patients prefer to be treated close to home, and value locally accessible services. For this reason a policy of "localised where possible, centralised where necessary" (Darzi, 2007) has been increasingly adopted by UK healthcare services.

This process can be traced back to the landmark NHS Plan which was introduced to 'give the people of Britain a health service fit for the 21st Century: a health service designed around the patient' (NHS, 2000). This emphasis on patient focus led to formal consultation with patients and public, with a resulting understanding of the value of treatment delivered closer to home. Healthcare delivered in community settings is more convenient and cheaper for patients, since it reduces the time and travelling required. It is also seen as more personal and accessible, and has associated benefits in terms of reducing the risk of healthcare acquired infections.

The shift towards community based care is supported by various incentives in the current commissioning system, and is in the process of being widely implemented by Strategic Health Authorities and Primary Care Trusts throughout the UK. Similar initiatives are also being adopted in other developed countries, particularly mainland Europe.

The policy has been applied to both routine and urgent (also known as unscheduled or emergency) healthcare, and has found particular support and success in the delivery of services that meet urgent healthcare needs. Urgent care is defined as 'the range of responses that health and care services provide to people who require – or who perceive the need for – urgent advice, care, treatment or diagnosis. People using services and carers should expect 24/7 consistent and rigorous assessment of the urgency of their care needs and an appropriate and prompt response to that need' (Department of Health, 2006a).

The case has never been better for delivering urgent healthcare in the community, as opposed to hospital settings. Those over 65 are healthier and are living longer, and 75% of NHS users are now aged 65 and over (Health Development Agency, 2005). By 2031 the number of people over 65 will grow to 15.8 million; a 60% increase (Government Actuary Department, 2007). These individuals have a great deal to gain from the community delivery of urgent care because they are less mobile and more dependent on community support than their younger counterparts. Furthermore, there is growing concern regarding systemic pressures on the UK health care system. A 2001 report (Department of Health, 2001) found that emergency admissions in the UK had risen by 20 per cent in the previous ten years. Increasing pressures on the emergency system are the result of a complex arrangement of factors. For example, General Practitioners are no longer required to provide out of hours services (Woollard, 2007).

Several national initiatives have been launched in the past decade to deliver urgent care closer to home, and provide suitable alternatives to hospital based urgent care services (usually an emergency department). These include:

- A national network of Walk-In Centres, designed to reduce demand on out-of-hours primary care and emergency departments
- NHS Direct (NHS 24 in Scotland), providing telephone and internet-based advice 24 hours a day
- The establishment of Urgent Care Centres and GP-led Community Health Centres with extended opening hours and additional diagnostic and treatment facilities
- A change in philosophy within UK ambulance services, moving from a transport service to a mobile treatment service

The last of these is particularly important, because of the demands placed on the UK ambulance service. There were 6.3 million 999 calls made in England during the year 2006/07, an eight per cent rise on the previous year and almost double the number of calls received 10 years previously (Woollard, 2007). This inexorable rise in demand will lead to a corresponding rise in hospital emergency department attendances, and emergency hospital admissions, unless steps are taken to prevent this.

The emergency ambulance service is therefore undergoing a transformation from an organisation designed to convey patients to hospital, to a professional group that is capable of assessing urgency and delivering the appropriate treatment to the patient; providing the right response, first time, in time (Department of Health, 2005a and 2005b).

1937
Introduction of UK-wide 999 emergency telephone number.

1948
Birth of the NHS.

1957
Peter Safar publishes the first description of the modern cardiopulmonary resuscitation (CPR) technique.

1964
Miller Report is published and recommended that ambulances should provide treatment as well as transportation.

1974
ORCON targets are introduced to help monitor the performance of ambulance services.

1991
57 NHS Trusts are established.

1998
NHS Direct (NHS 24 in Scotland), providing telephone and internet-based advice 24 hours a day.

2000
NHS Walk-In Centres, designed to reduce demand on out-of-hours primary care and emergency departments.

2004
Ambulance service attended 4.26 million 999 calls in England and 76.2% of Category A life threatening calls are reached within the eight minute target.

2007
NHS is ranked 17 in a list of top healthcare services in Europe.

2008
NHS is the largest employer in Europe with 1.3 million employees.

Treatment System Ergonomics

The treatment system consists of two pods: (1) a mobile treatment space and (2) portable treatment packages of equipment and consumables (based on the current responder bag concept). Data identifying requirements for both pod types were required to explore and develop a range of portable packages and provide a clinical environment for diagnosis and treatment.

Observation data were used to generate findings for both the mobile and portable treatment units. For the portable treatment package, data were collected regarding small scale equipment and consumables used. For the mobile treatment unit, data were collected regarding larger scale equipment used and procedures followed (for example blood testing, or patients needing to reside on observational wards for short periods). The observations yielded a large amount of data for both the mobile treatment unit and the portable treatment packages.

Treatment of patients presenting with one of the six outlined complaints was observed at two emergency departments (Bristol Royal Infirmary and Leicester Royal Infirmary, acute care) and one Walk-In Centre (primary care). Observational, task description data were collected from 84 patient treatments. The data were analysed using Link Analysis and Hierarchical Task Analysis to record the equipment and consumables used, staff movements made, and clinical procedures followed. Staff interviews were carried out following some treatments to gain a better understanding of the procedures followed to aid the analysis. NHS ethics approval was obtained from LNR1 REC (ref: 07/A2501/104).

A full size mock-up of the patient compartment from a Mercedes Sprinter emergency ambulance was constructed in the laboratory (see figure 19, right). It was equipped with equipment and consumables e.g. stretcher, oxygen cylinder, defibrillator, syringes, sharps bins, connecting tubes, carry chair, suction unit, responder and drugs bags. A patient simulator (SimMan©) was programmed to simulate a chest-pain presenting complaint that developed into a cardiac arrest. A monitor displayed patient status information: blood pressure, respiration rate and oxygen saturation. The status of the patient changed during the scenario (for example, changed heart sounds, blood pressure, breathing rate and vomiting) and additional clinical information was available on request (Hignett et al, 2009).

Data were collected with six ambulance crews from East Midlands Ambulance Service NHS Trust and recorded with multi-directional video cameras.

Link analysis was used to record the movements in the system with link diagrams and coded thematically into three primary codes (repeated movements, team physical interface and lay down space) (see figure 22, page 77).

Figure 19, right
Mock-up of an emergency ambulance patient compartment. This example is based on the internal dimensions of a modular van type.

What Happens In The...

Emergency Department

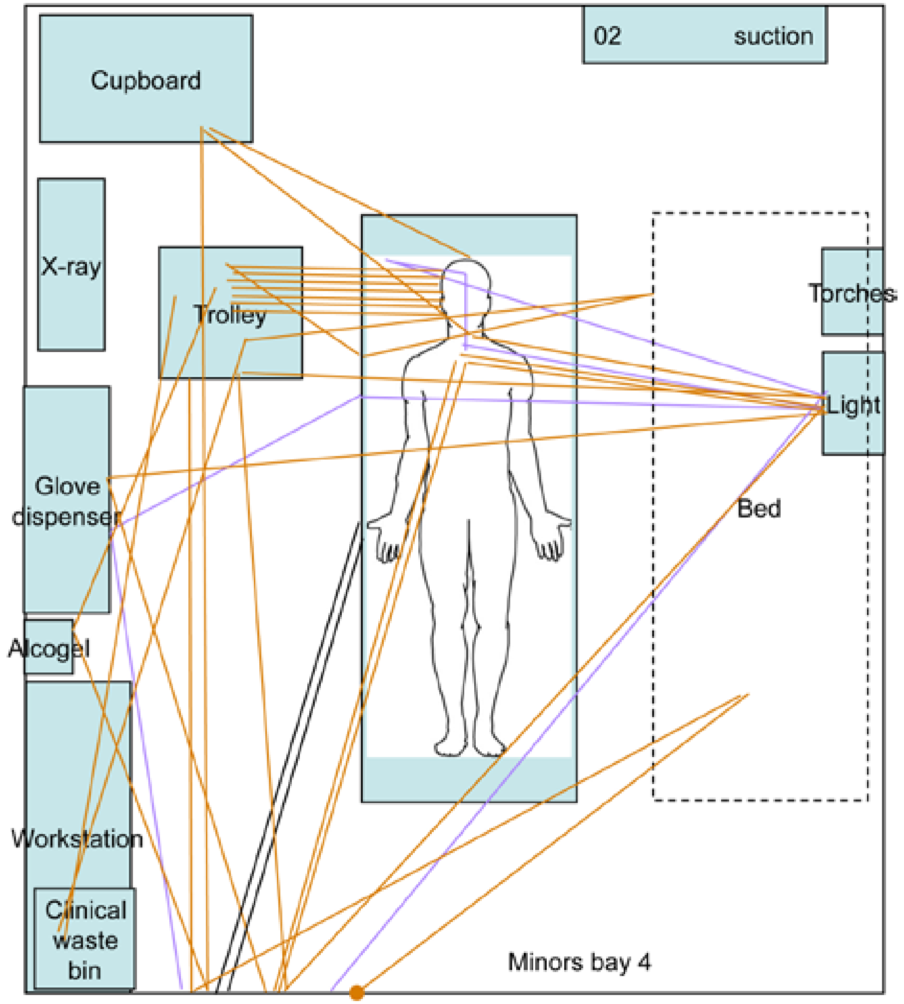


Figure 20
Link Analysis of laceration assessment and treatment in an emergency department treatment room.

#	TASK	NOTES
1	Dr entered cubicle	
2 2.1 2.2	Put gloves on Took gloves from cabinet Put them on	Gloves required Cupboard utilised
3	Moved to patients side	
4 4.1 4.2 4.3	Removed bandage Got scissors out of pocket Cut bandage Put scissors back in pocket	 Scissors required Pocket used to store kit
5 5.1 5.2	Put light on Moved light across patient Pressed switch	Light required Adjustable light required
6 6.1 6.2 6.3 6.4	Assessed wound Took bandage away Looked at wound Switched light off Moved light	
7 7.1 7.2	Asked patient questions Are you normally fit and well? Do you have any allergies?	
8 8.1 8.2	Explained treatment path Explained would clean wound and stitch Explained would give pain killers	
9 9.1 9.2 9.3	Wrote notes Left cubicle Went to main ward Wrote notes	Notes taken and workstation required Leave cubicle Another work area used Notes taken
10	Nurse entered cubicle	
11 ...	Put light on ...	Light required

Table 7
Excerpt from Hierarchical Task Analysis for laceration assessment and treatment in an emergency department treatment room.

What Happens In The...

Walk-In Centre

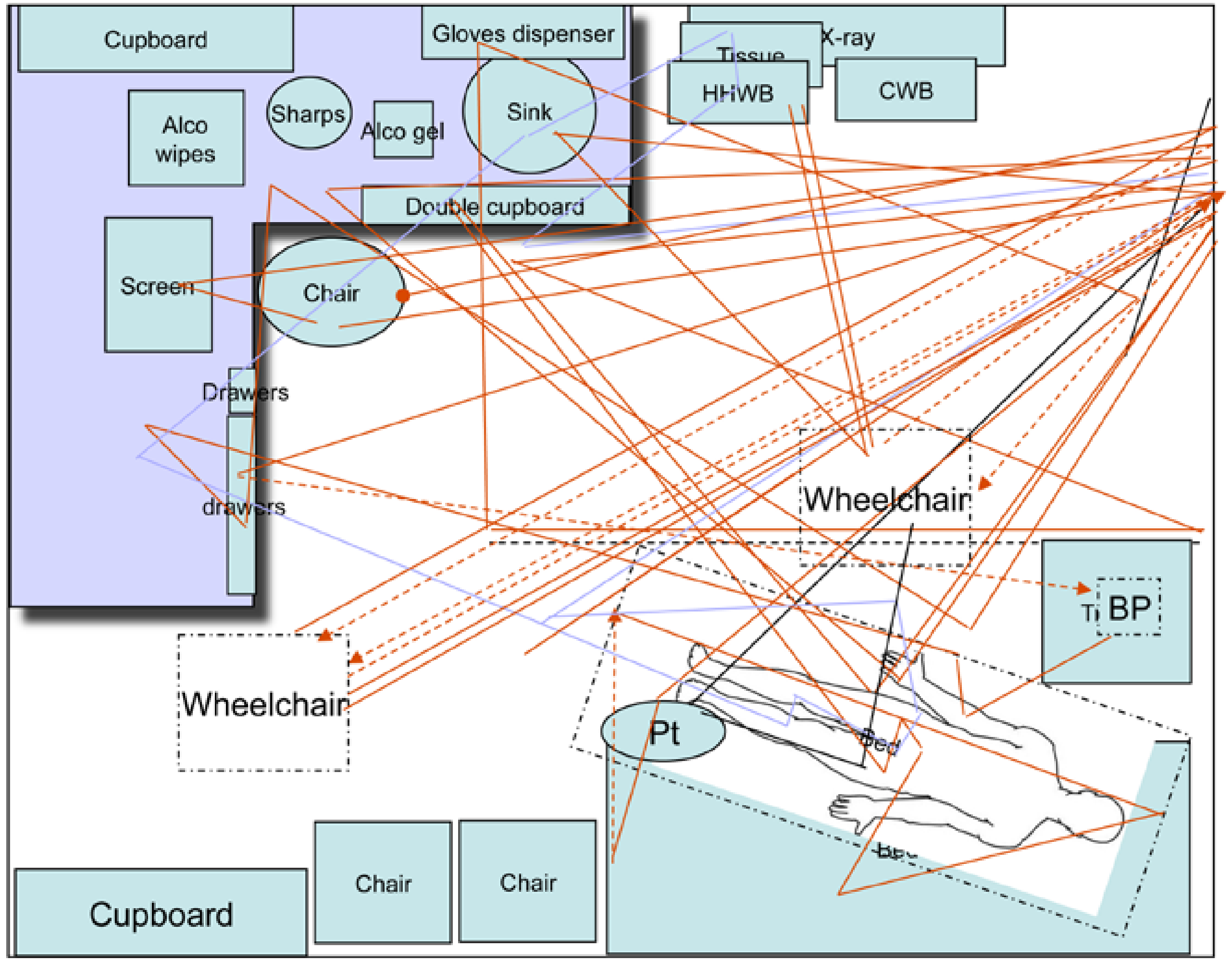


Figure 21
Link Analysis of fall assessment and treatment in a Walk-In Centre treatment room.

#	TASK	NOTES
1	Emergency Nurse Practitioner (ENP) entered room with patient	
2	ENP stood at sink facing patient	
3 3.1 3.2	ENP asked patient questions Asked about incident Asked about pain killers	
4 4.1 4.2 4.3 4.4 4.5 4.6 4.6.1 4.6.1.1 4.7 4.8 4.9 4.9.1 4.10 4.10.1 4.10.2 4.10.3 4.10.4 4.10.5 4.11 4.11.1	ENP assessed patient Pulled curtain across Took gloves from dispenser Asked patient to take trousers off Locked door Asked patient more questions Checked for pain sites Felt down spine Felt from upper spine to lower spine Felt down patients legs Felt patients sides Felt around hips Moved to patients side Checked motion Asked patient to move leg forward Asked patient to move leg back Asked patient to move leg to the side Asked patient to move leg across his body Asked patient to raise arms Checked pain sites Felt shoulder for pain	 Privacy required Glove dispenser required Lockable facilities required Movement around patient
5 5.1 5.1.1 5.1.2 5.2 5.3 ...	Released brakes on bed Released brake off foot end Went to foot end of bed Pressed on brake with foot Moved bed out slightly Released brake off head end ...	Bed required Movement of furniture

Table 8
Excerpt from Hierarchical Task Analysis for fall assessment and treatment in a Walk-In Centre treatment room.

What Happens In The...

Emergency Ambulance

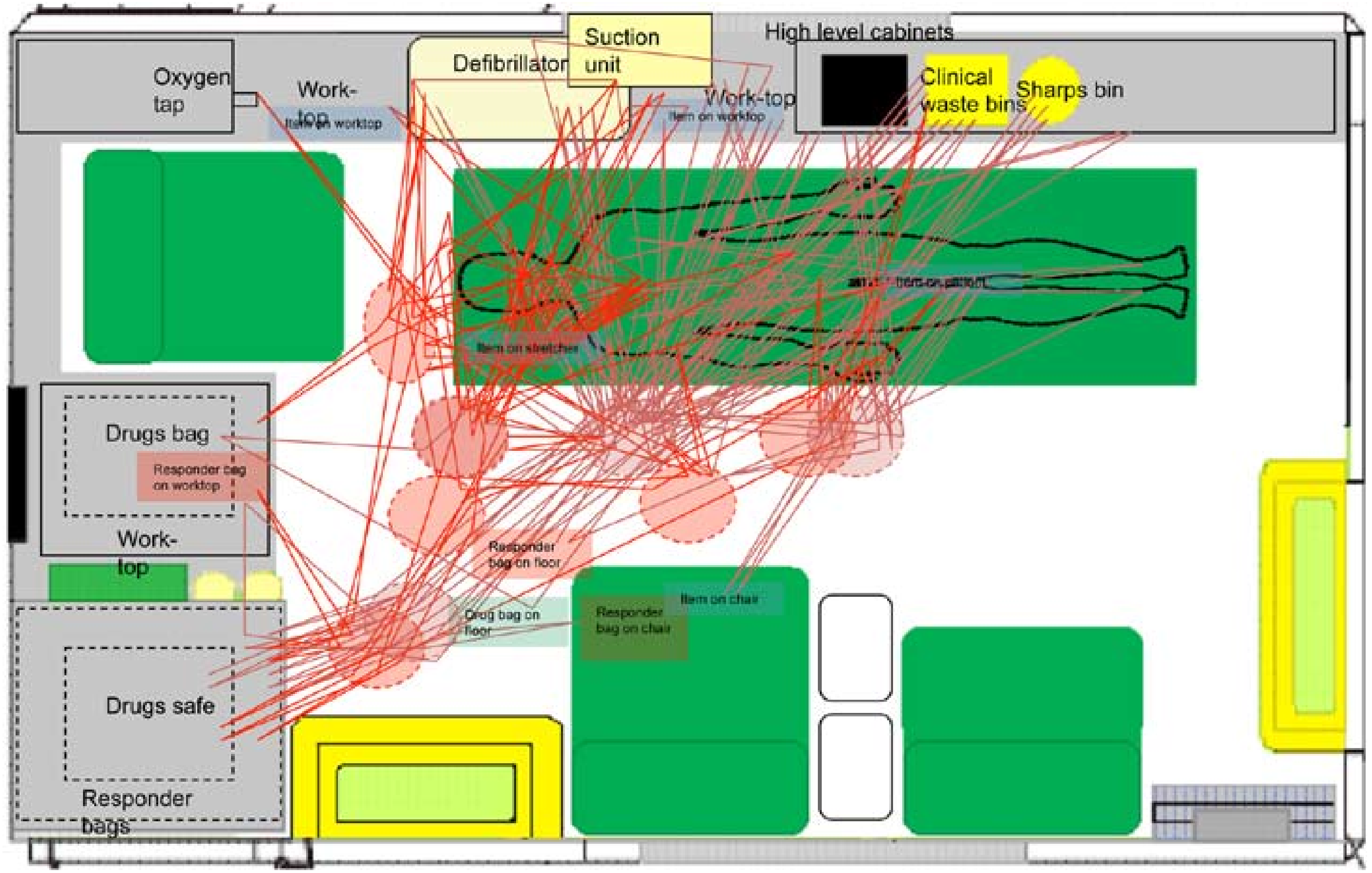


Figure 22
Link analysis for simulation experiment of chest pain scenario (bulkhead window) - see table 9, right, which provides background information about the patient scenario.

A comparison was made for two current emergency ambulance layouts; with a bulkhead window and a bulkhead door (Hignett et al, 2009). The SimMan© was programmed to simulate a chest-pain presenting complaint that developed into a cardiac arrest. A monitor displayed patient status information: blood pressure, respiration rate and oxygen saturation.

Six emergency crews participated in the simulation experiments and link diagrams were analysed to determine the working activities.

It was found that there was a lack of lay down space for responder bags, equipment and consumables and limited access to the equipment and consumables necessary to perform a full range of clinical tasks and services from a safe position for this scenario. As only one clinical scenario was used, there might be different findings for different clinical activities. The analysis suggested that the bulkhead window layout provides the best use of limited space in emergency ambulances

Name John Smith
Gender Male
Age 65 years
Height 1,700 mm
Weight 75 kg
Background The patient has been shopping in a large supermarket for over an hour. He went to the bus stop to return home and started experiencing pain.
Setting The patient was at the bus stop experiencing severe chest pain after shopping. When the ambulance arrived on the scene, the crew transferred the patient to the vehicle on the carry chair and then transferred him to the stretcher inside vehicle. The patient is now lying on the stretcher. No treatment has been given.
Patient information The patient is pale, grey and clammy, experiencing central chest pain radiating to left arm.

Table 9
Information generated for a simulated chest pain complaint - see figure 22, left, which shows the link analysis for this simulation experiment.

Treatment Space Package: Derived From A Chest-Pain Scenario

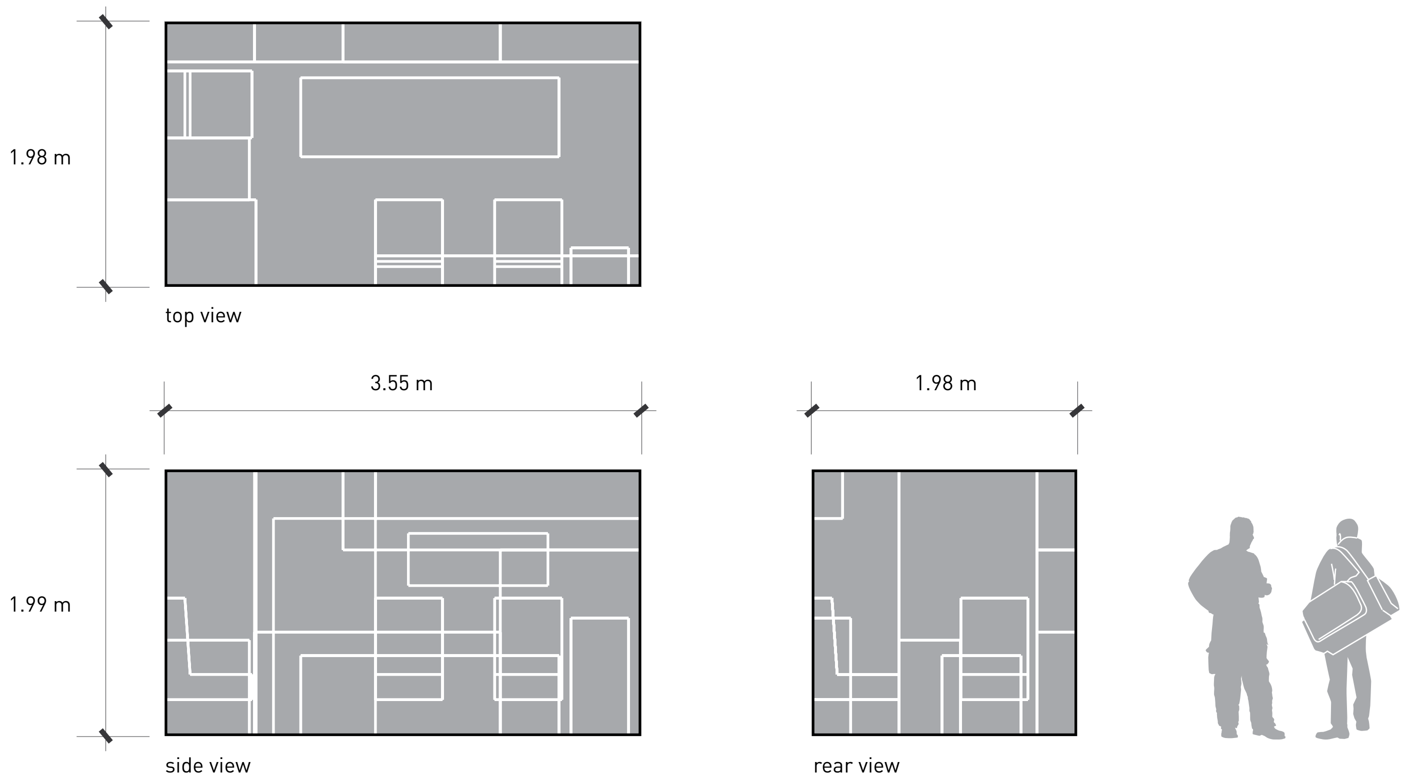
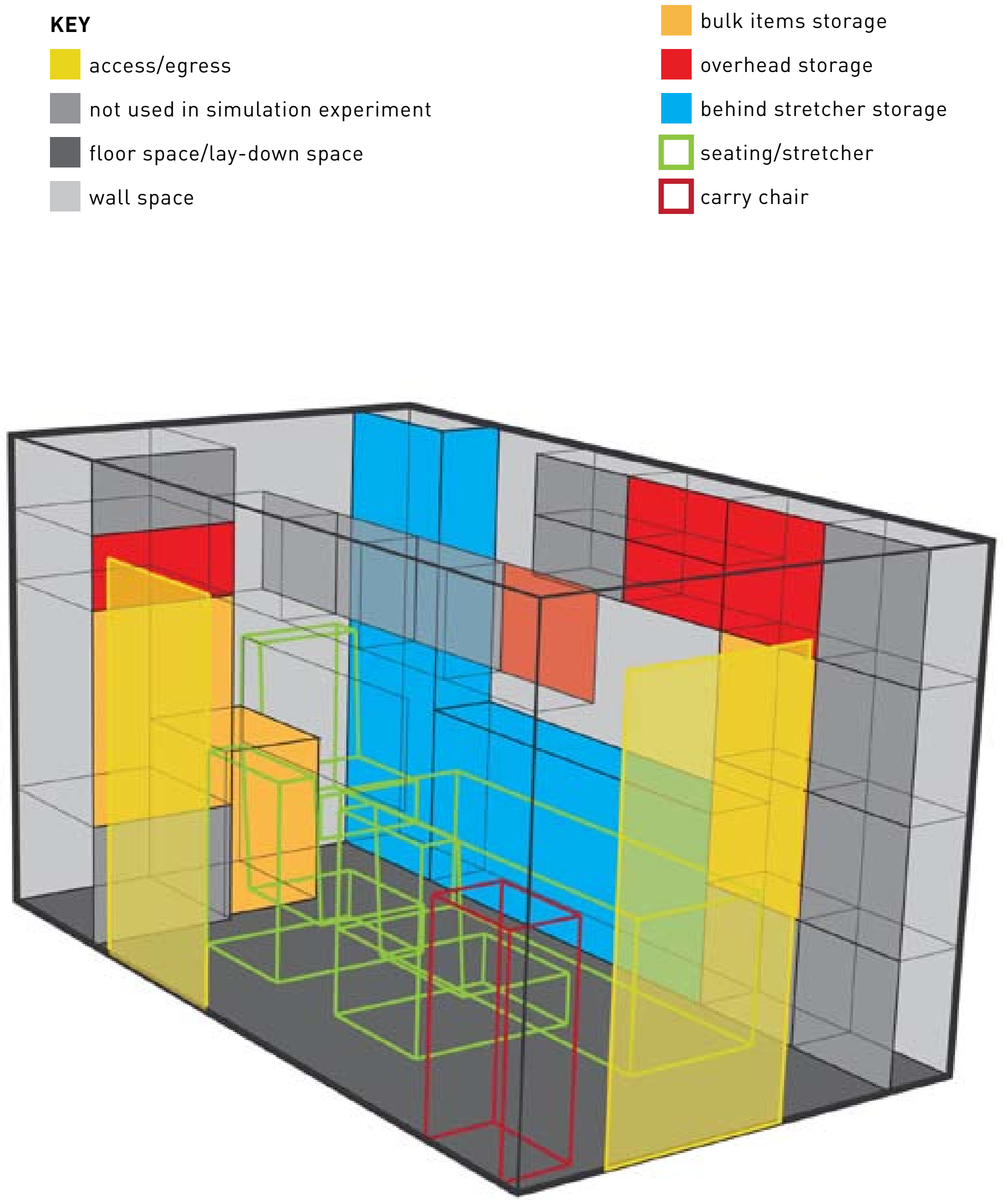


Figure 23, above
Orthographic diagram of the treatment space package including stretcher, seating and cupboard space.

Figure 24, right
Treatment space configuration derived from a chest pain scenario to demonstrate the areas being used to perform a specific treatment type.



Mobile Treatment Space

The mobile treatment space is complex, with design requirements grouped into seven categories (see table 10, right). There are similarities with previous research to look at the design of future emergency ambulances (Hignett et al, 2009), but it is encouraging, and in keeping with the project's overall objectives, that the mobile treatment space design requirements focus on clinical provision in the community rather than stabilisation and transportation to hospital.

Diagnostic facilities are likely to be available as portable equipment (taken to the patient) as well as mobile equipment (available within an urgent response vehicle). The work station requirements are more complex, reflecting the increased level of communication that is required to support enhanced assessment, treatment and discharge, for example high quality video, vital signs, voice and text communication and patient information exchanged in real-time with the remote clinical specialists. ECPs spend longer assessing and treating patients than paramedics, and often need to access both sides of the patient. The mobile treatment space will need to be adaptable to ensure the working environment is suitable for all likely treatments. The Fleet Managers considered that the results identified a need for a specifically designed urgent care vehicle to support the role of the ECP.

Although the concept of modularisation has been called the goal of good design (Gershenson et al, 1999) the challenge for the design of modular products/systems is to maximise flexibility. It is essential to retain clinical autonomy in diagnosis and treatment, and a degree of flexibility is therefore necessary to support individual variations (for both clinical practitioners and patients). Further research is needed to determine which equipment and consumables should be carried in the portable treatment packs and which should be carried/stored in the mobile treatment space.

Seven design requirements were identified for the mobile pod: diagnostic facilities, sanitation facilities, adequate furniture for treatment, suitable environment for clinical and functional use, essential drugs and gases for patient treatment, care taken over patient experience and a suitable workstation for support and administration work (see table 10, right). These elements should all be incorporated into the design specification in order for the mobile treatment space to offer the same quality of care as an acute hospital or primary care unit.

PRIMARY CODE	SECONDARY/TERTIARY CODES
Diagnostic	1) Heart Monitor, BP, ECG (3- or 12-lead) 2) Testing: urine, blood, MRSA, vision 3) X-ray including reading and 2nd opinion
Sanitation	1) Bathroom facilities and clinical wash hand basin 2) Disposal: domestic, clinical, sharps bags/bins/boxes 3) Dispenser: alcogel, soap, towels, aprons, gloves
Furniture	1) Lay down space, including treatment/dressings trolley 2) Staff chair 3) Patient chair/treatment couch (adjustable) / limb rest 4) Other, e.g. clock, information board
Environment	1) Space to move around patient, re-arrange furniture, multiple staff, family members 2) Lighting
Drugs and gases	1) Gas cylinders (entonox, oxygen) 2) Secure drug storage 3) Drugs, e.g. GTN, aspirin, morphine, thrombolysing drugs, anti-inflammatories, antibiotics and others
Patient experience	1) Privacy (curtain) 2) Security for possessions 3) Dignity (gown) 4) Comfort (blanket, sheet, pillow) 5) Drinking water
Work station	1) Communication with other departments/specialists, community services and for 2nd opinion 2) Administration work station: computer, telephone

Table 10, above
Mobile treatment space design requirements.

Figure 25, above left
A concept vehicle with a deployable shelter that could be used as a mobile treatment space. This concept was designed by Andrew Maynard Architects. Visit www.maynardarchitects.com for more information. For this type of concept, ease of redeployment is a serious consideration.

Portable Treatment Packages

In 2008 a further workshop was held with fleet (4), clinical (5), service (4) and health and safety managers (2) from five Ambulance Trusts to present the findings of the 2007 workshops, audits and observations. Data were collected as a series of semi-structured questions in individual workbooks, for example:

• How might medical equipment used by the ambulance service be:

a) Better organised, laid out and accessed in vehicles?

b) Effectively rationalised to provide what is needed without carrying excessive or unnecessary stock?

• How do you see the role of portable kit and diagnostics changing:

a) By 2015?

b) By 2025?

The written responses were entered into NVivo (Bazeley, 2000) for analysis. NVivo is a qualitative data management programme that supports coding, searching and theorizing.

An audit of portable equipment (used by Fast Responders/Paramedics) was carried out in 2002 (Redden, 2003). This was updated in 2008 for ECPs (Reynolds, 2008). Observational data were collected from 84 patients at EDs and Minor Injuries Units presenting with the six complaints identified from the 2007 workshops (Jones et al, 2008a). Data were recorded with Link Analysis (Jones et al, 2008b) with supplementary field notes for equipment and consumables requirements.

The 2007 workshops produced a list of equipment and consumables, grouped by clinical criteria. These were compared with the audits and the observational data to give a proposed generic list of equipment and consumables (see table 11, right).

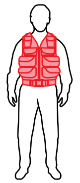
An audit of portable items used by ECPs was carried out to review the use of equipment and consumables (Reynolds, 2008). In 2008 a further workshop was held with fleet, clinical, service, and safety managers from five Ambulance Trusts to present the findings of the 2007 workshops, audits and observations. Data were collected as a series of semi-structured questions in individual workbooks (Hignett et al, 2009). Finally, design decision groups were held to challenge current practice (with word maps and round-the-table questionnaires) and support innovative re-design through mock-ups/prototypes (Wilson et al, 2005). Staff were given an opportunity to prepare treatment packs for specific care pathways and carry out a drawing exercise to create packs with improved functionality and usability. For the second session, working prototypes were used as the focus for the discussion and modification of the design requirements.

The results suggest that the response kit for ECPs should consist of two components; a clinical workspace (equivalent to an emergency department treatment trolley) and storage. Specific equipment and consumables were identified for the treatment pack for the initial assessment: BP cuff, thermometer, BM kit, urinalysis, opthalom/otoscope, KY jelly, apron, peak flow meter, patient record form, clinical disposal/sharps, tongue depressor, tendon hammer. Additional packs were suggested for suturing, dressings (including pressure sores), catheter care, maternity, IV access, cardiac/respiratory care and treatment. A single-use, modular pack concept emerged as the preferred approach to provide efficient clinical treatment and also improve infection control issues, restocking and storage. This will be explored in a wider context in future research to look at the role for single use packs in urgent care.

TREATMENT GROUPS	EQUIPMENT AND CONSUMABLES
Minor wounds	Dressing pack, Irrigation fluid, forceps, scissors, tissue glue, steristrips, suture kit (sutures and instruments)
Ear, nose and throat	Tongue depressors, thermometer (tympanic), suction, auroscope
Respiratory	Oxygen, masks (including tracheotomy), stethoscope, pulse oxymeter, nebuliser, nasal and oral airways, peak flow meter, suction kit
Blood monitoring	Specimen bottles, phlebotomy kit, blood pressure cuff, cannula (various), giving sets, blood glucose testing strips
Eyes	Irrigation fluid, eye pads
Basic life support	Defibrillator, oxygen, face mask, electrocardiogram (ECG) capability (computerized transmissible)
Communications	Mobile telephone, tele-medicine capability, on-line decision support software
Urinary	Urinalysis kit, sample bottles, catheter equipment, incontinence pads
General	Gloves (sterile/non sterile), neck collar, bandages, gauzes, dressings, waste bins (sharps, clinical, domestic), sphygmomanometer, skin preparation wipes, apron, handwash facilities, tissues, syringes, needles, lubricant, magnifying glass, razor, tweezers, scissors, referral letter/x-ray/prescription (prescribing guidelines), patella hammer, ring cutter, safety glasses, helmet
Drugs	Glyceryl trinitrate (GTN) spray, aspirin, intravenous fluids, paracetamol, anti-inflammatories, antibiotics, local anaesthetics

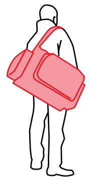
Table 11
Observational data for equipment and consumables from emergency departments and minor injuries units

Typology of Portable Equipment

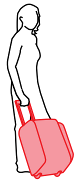


Wearable
Including combat trousers, utility vests and utility belts, this type of portable storage is used to varying extent in the ambulance service. Utility vests are used more widely by the police.

Grab bag
A compact and practical method of transporting treatment packages, grab bags are already in use by ECPs in London Ambulance Service. They can be modularised and colour coded for ease of use.



Holdall
This type of bag is used throughout the ambulance service as a responder bag either with a single strap or rucksack type strapping. It is often embellished with multiple external pockets for ease of access.



Pullalong
The pullalong has great potential for enabling clinicians to deliver routine and urgent care in the home. The bag can be opened to create a large footprint and practical clinical workspace.

Trolley
Trolleys are used a great deal in emergency departments for a range of treatment types. They tend to be heavy and cumbersome and so not practical for mobile healthcare scenarios with a single clinician.

Case Study

Army: Military Medical Protocols

To cope with extreme scenarios the Army employ three medical platforms and medical capabilities are defined by modules (kit, skills and mobility).

Key learnings include: 1) command and control 2) modules and 3) robust operations.

Background
There are distinct differences between civil and military ambulance service platforms. The military operate under extreme conditions and as a consequence command and control dominates the provision of medical care.

The importance of dedicated medical teams was realised in the American Civil War during 17th century, and this model was adopted by many of the countries fighting in World War 1. Dr J Letterman established ambulance units to transfer wounded soldiers on stretchers to a 'primary station'. From these dedicated locations the wounded soldiers were later conveyed to field hospitals for treatment. Conveying wounded soldiers between designated locations ensured that they were in the care of trained medical teams and thus increased the likelihood of survival and recovery. However, the main objective of military medics is to maintain a fighting force, so whenever possible a soldier is treated on-scene and kept out of hospital. The British Army's philosophy for medical provision is as follows: 'Provide service personnel in the UK and overseas both in operational and non-operational areas, with timely, appropriate access to healthcare of a clinical standard as close as possible to that pertaining in the NHS.' (Armed Forces Overarching Personnel Strategy, Chapter 3, Annex B: Personnel Strategy Guideline 19, Health Policy).

Medical platforms
The three medical platforms employed by the Army are: evacuation; treatment; and command and control. These three platforms provide insight into proven acute medical care protocols that have to be effective even in the most extreme conditions.

The evacuation platform includes field hospitals – provision of at least 50 beds for every 800 persons, which operate a 'consultancy driven service'. The medical teams are often trained in the NHS, so army medics tally with NHS qualifications, such as paramedic and consultant.

Battlefield injured soldiers are evacuated to hospital if they cannot be adequately treated on-scene. The target is to get patients to hospital within two hours. If the hospital is further than two hours away a clinician is delivered to the patient. If the distance to hospital is greater than four hours, or if there are multiple casualties, then a hospital module, or theatre module (slice of the hospital) is delivered to the patients within 12 hours. Triage of the patients takes place at a regimental aid post, to which patients are transported. There are usually two operating within a Regiment (2,000–3,000 personnel) to enable them to keep up with the 'front line' of the battle. Regimental aid posts are made up of a vehicle and temporary structure, such as a canopy or tent. They are operational within eight minutes once on-scene and are staffed by a ten-person team including a doctor, nurse, a triage sergeant, corporal and six medics.

The treatment platform ensures that every soldier is first aid trained and carries a triage card and first aid pack, including quick clotting bandages. One quarter of Army personnel are trained combat medics and carry more kit and consumables, including morphine. Five in every 100 are trained paramedics, equivalent to NHS training standards.

The medical command and control platform responds to the dynamic situation. For example, should a nine-line call be broadcast by a soldier on the battlefield (see table 13, right) to indicate that there has been an incident, command and control decides what the correct medical response will be. In addition, command and control predicts the numbers of battlefield casualties and non-emergency healthcare requirements and ensures that resources are in place to meet these requirements.

Modules

The delivery of medical care is broken down into modules. Each module is based on a capability, which is defined by the clinician's skill level, appropriate kit and consumables, and means of delivery. For example, the 'trauma module' includes the appropriate kit and consumables coupled with the clinician who has the necessary skills to use that equipment effectively. It carries enough stock to treat up to 20 people. And the 'primary healthcare module' for disease and non-battle injury is essentially a mini pharmacy, equipped to keep the fighting force as fit and healthy and possible. These examples are typically based in a regimental aid post.

DESCRIPTION	PERSONNEL	MEDICAL CARE
Unit	4	Every soldier is first aid trained and one is a trained combat medic
Squadron/Section	8-16	
Platoon	25-60	
Company	70-250	
Battalion/Battle Group	300-1,000	One field hospital for every 800 soldiers
Regiment	2,000-3,000	Two regimental aid posts, each manned by 10 person team (doctor, nurse, triage sergeant, corporal and six medics)
Brigade	3,000–5,000	500 medical staff per 5,000 persons
Division	10,000–20,000	
Corps	30,000-	

Table 12, above
British Army medical provision overview.

Table 13, right
The nine-line call, which is used by soldiers to inform command and control about incidents and enable them to make a decision about the most appropriate medical response for that individual.

LINE	PRIMARY	SECONDARY
Line 1	Location of the pick-up site	
Line 2	Radio frequency, call sign, and suffix.	
Line 3	Number of patients by precedence	A - Urgent B - Urgent Surgical C - Priority D - Routine E - Convenience
Line 4	Special equipment required	A - None B - Hoist C - Extraction equipment D - Ventilator
Line 5	Number of patients	A - Litter B - Ambulatory
Line 6	Method of marking pick-up site	N - No enemy troops in area P - Possible enemy troops in area (approach with caution) E - Enemy troops in area (approach with caution) X - Enemy troops in area (armed escort required)
Line 7	3,000–5,000	A - Panels B - Pyrotechnic signal C - Smoke signal D - None E - Other
Line 8	Patient nationality and status	A - UK Military B - UK Civilian C - Non-UK Military D - Non-UK Civilian E - EPW
Line 9	NBC Contamination	N - Nuclear B - Biological C - Chemical

Technicians, paramedics and doctors carry modules in the form of backpacks, which are equipped according to their respective level of training. However, the amount of kit carried is usually trimmed down considerably, for example if the clinician is working out of a helicopter.

Modules are packaged according to predicted 'need' and dispatched when necessary. Once in place, logistics are established to restock the modules. There are two groups of modules, which are: disease and non-battle injury; and combat trauma and battle casualty management (see image, page 86).

Ambulances

Army ambulances are modified military vehicles. The type of vehicle used is determined by the vehicles the ambulance is designed to operate alongside. In other words, a family of vehicles are produced on the same vehicle platform, which makes maintenance easier and more cost effective and improves economies of scale.

Current military vehicles are designed for fighting and carrying soldiers and equipment. Thus, the role of an Army ambulance is as follows: 1) mobility; 2) protection; and 3) provide care.

Ambulances are typically crewed by 3–4 personnel including a driver, commander and clinician. They carry a module designated to the vehicle, such as an 'ambulance module', as well as each clinician's individual module.

Combined, the medical platforms, modules and ambulance design ensure the highest level of medical care, even under the most extreme circumstances.

Future Vision

Evolution of the service (emergency and urgent)

Revolution

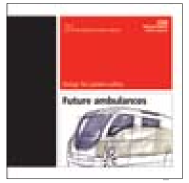
Healthcare on the Move
Exhibition 2009

Smart Pods Phase 2
Exhibition 2013

NPSA Future Ambulance Project

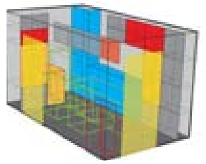
Smart Pods phase 1

Smart Pods phase 2



NPSA Future Ambulance Project
Recommendations
- Consultation process
- Performance requirements
- Design evolution process through national ambulance service standardisation programme in collaboration with manufacturers
- Blue sky design opportunities

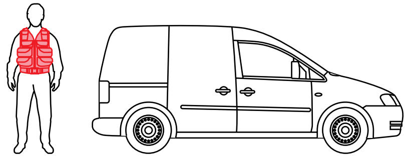
Mobile Treatment Space
Evaluating the treatment space
- Ergonomic study
- Recommendations



Portable Treatment Capability
Redesigning the system
- Kit list consultation
- Performance requirements
- Scoping study

Integrated system: mobile and portable solutions
Enabling distributed healthcare
- Taking research into practice

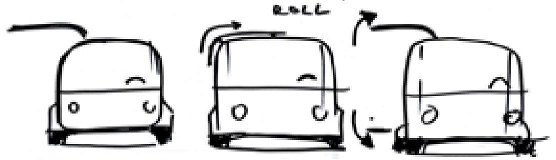
Wins: mid-term integrated system solution propositions



Vehicle conversion mock up

Revolution
- Future-proof development

Phase 2 design proposals leading into clinical trials



Demonstrator

Smart Pods phase 1

Smart Pods phase 2

New Vehicle Typology
Recommendations
- Blue sky design opportunities
- Scoping

New Vehicle Typology
Design and development
- Consultation process
- Performance requirements
- Design development

Phase 2 design propositions

Method

The project was devised and delivered using five, inter-connected work packages. These overlapped in multiple domains, but are separated here for ease of description.

Work Package 0: Team formation, pre-project access, ethical approval and research governance at all participating sites
The team was initially formed though an EPSRC "Ideas Factory" event, and subsequently consolidated throughout the project lifetime. We consider the diversity and expertise of the team, catalysed by the EPSRC's innovative approach to funding, as a particular strength of the Smart Pods initiative. All ethical and research governance approvals were gained at the start of the project, with initiation at the partner clinical sites. Written consent was obtained from all participants (both patients and staff).

Work Package 1: Operations management and procurement
WP1 had two streams: the first was operations management based, modelling combinations of distributed resources by drawing upon recent supply chain and postponement theory to simulate key parameters. Relevant supply chain literature was reviewed, in conjunction with case studies of leading organisations (for example, Virgin, RAC, Tesco) whose responsibilities involve combining resources in real time.

Current and likely future emergency ambulance activity was reviewed and analysed into core domains to inform equipment and supplies design combinations. The required combinations of staff, equipment and supplies were then modelled physically and, using computer based modelling provided initial validation of the required synchronisation of capabilities.

The second stream was procurement-based. The procurement analysis deduced existing costs by analysing existing practices across the treatment spectrum to provide a baseline for comparison with the new model of care. We identified the full procurement costs associated with current fixed, hospital-based provision to provide a baseline for identifying a business case for new distributed provision. A meta level, but empirically derived, framework for how current costs are allocated was created, comparing current and distributed procurement costs.

Work Package 2: Ergonomic analysis of clinical activities
Stakeholder workshops were held for each of three domains: ambulance; hospital (emergency departments), and community (minor injuries units and urgent primary care). This determined the range of treatment activities to be included.

Observational and interview data were collected at two sites (East Midlands and South West England) for the identified treatment activities in order to analyse the performance of clinical tasks, including the frequency of task occurrence and physical performance. Hierarchical Task Analysis (HTA) was used to describe the detailed actions and plans occurring in the tasks as well as the range of differences in task activities and order. Physical movements were recorded and analysed using Link Analysis (LA), where links were defined as movements of position and communication. The ambulance data were collected using simulations with an adult complete-crisis mannequin programmed to provide real-task scenarios in a healthcare ergonomics laboratory.

The outputs of this work were used to create detailed designs for both the patient treatment space and equipment bags required for a defined range of relevant clinical conditions.

Work Package 3: Vehicle design
Case study reviews of existing and potential manufacturing methods and technologies appropriate to meet likely UK and European demand were carried out to understand production and manufacturing options. This included an exploration of new and emerging low-volume technologies such as rapid prototyping and manufacture used in specialist arenas including motor sport. Vehicle engineering and associated systems were then surveyed, with particular regard to chassis/drive chain and intelligent vehicle technologies. This also encompassed sustainability issues in terms of full life-cycle energy usage, followed by the specific consideration of modularity and rapid reconfiguration.

The above considerations and findings were used as the basis of briefing documentation for a Masters vehicle design studio project, which explored a wide range of system and vehicle design options (see page 57).

In the latter part of the project a full team review of all system/vehicle design options, informed by the results of other work packages, reduced the options to a smaller number of potential alternatives, developed as mechanical and package layouts, 3D models and animation scenarios covering the full range of proposed applications. Iterative design evolution and testing against service and treatment models/requirements provided further refinement in preparation for public presentation and stakeholder/industry evaluation.

Work Package 4: Socio-technical framework
A survey of clinical staff in hospital, ambulance and community settings, as well as relevant stakeholder groups, was undertaken in the East Midlands and South West England to explore views on the delivery of urgent and emergency care in the community, on pertinent policies, and on the proposed multi-level component system to bridge the community and hospital provision of urgent care. Likely impediments to change and the strategies that may need to be adopted to engage stakeholders were also explored.

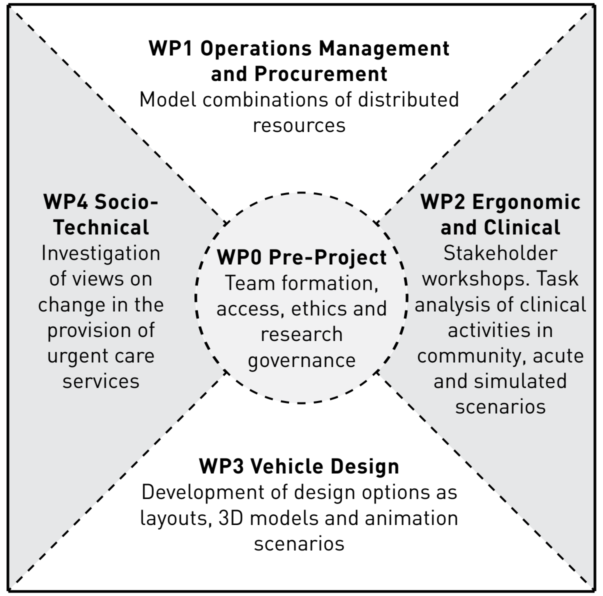


Figure 26
Overview of work package configuration

Stakeholder Mapping

The outputs of this research can only be successfully adopted into actual clinical practice if the problems and consequent solutions are viewed from all possible perspectives. Inputs should include those from all involved: patients; the public; 'frontline' clinical staff; healthcare managers; operational managers; commissioners and purchasers. To achieve this goal the multidisciplinary Smart Pods team worked with a range of stakeholders from the outset.

A stakeholder is any person, group or institution that has an interest in a development activity, project or programme. This definition includes both intended beneficiaries and intermediaries, winners and losers, and those involved or excluded from decision-making processes. Stakeholder analysis aims to:

- Identify and define the characteristics of key stakeholders
- Assess the manner in which they might affect or be affected by the project outcome
- Understand the relations between stakeholders, including an assessment of the real or potential conflicts of interest and expectation between stakeholders
- Assess the capacity of different stakeholders to participate.

The positions of key stakeholders were mapped onto a power interest matrix (see figure 27, right) using the following guidlines:

- High influence, interested people (key players): these stakeholders must be fully engaged
- High interest, less interested people (keep informed): provide sufficient information to these stakeholders to ensure they are up to date but not overwhelmed with data
- Low influence, interested people (keep satisfied): keep these people adequately informed, talk to them to ensure that no major issues arise
- Low interest, less interested people (monitor): provide these people with minimal communication to prevent boredom. For example, other department members and people unaffected by any chages.

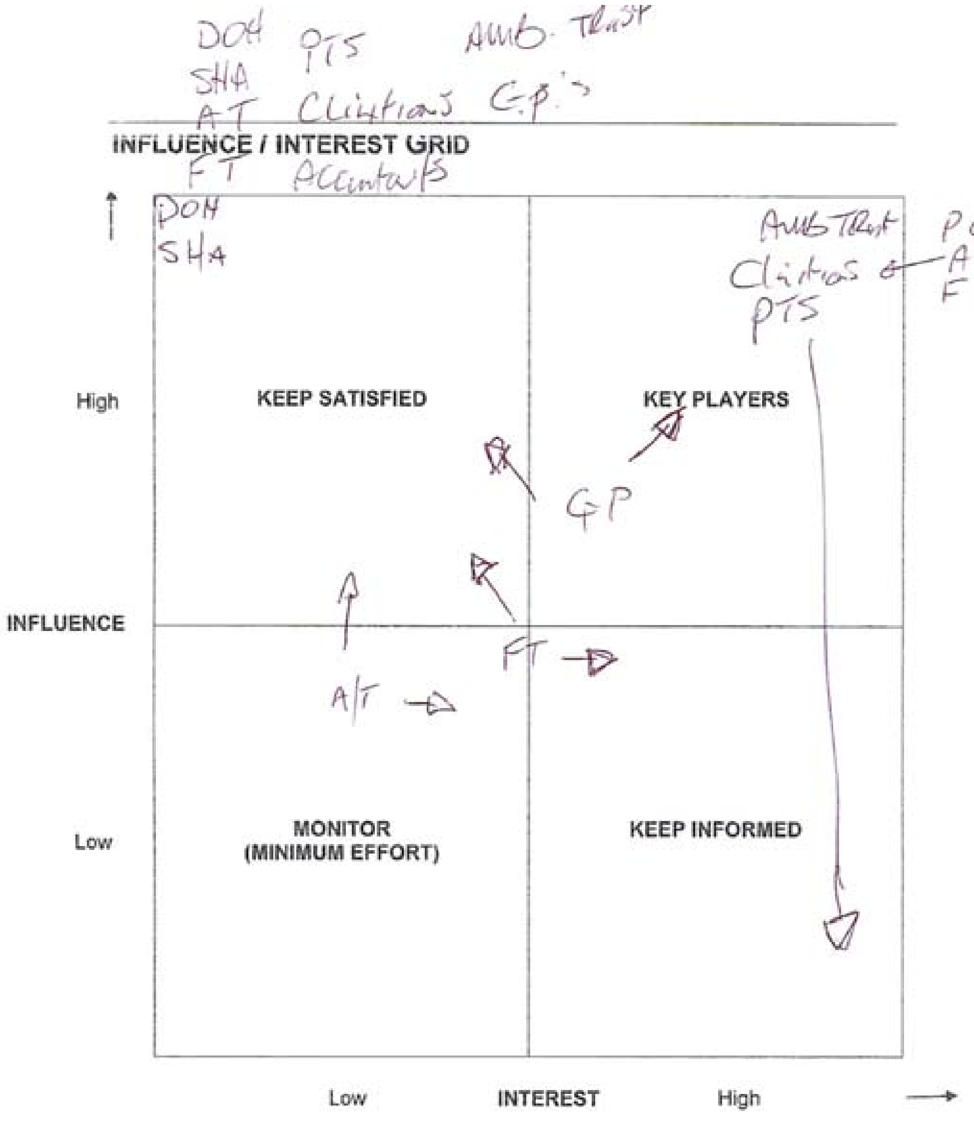


Figure 27
Stakeholder mapping: the power interest matrix

Stakeholder Workshops

Workshops were held in Loughborough (East Midlands) and Bristol (South West). Stakeholders from the three healthcare domains (acute, community and emergency care) participated in the workshops to identify presenting complaints that could be delivered in the community. The participants were recruited from the six NHS Trusts through the collaborating partner at each Trust. There were 12 participants from 2 East Midland Trusts, at the Loughborough workshop and 11 participants from three South West Trusts at the Bristol workshop. A professional facilitator co-ordinated the two workshops.

The research team agreed the desired outputs, as 1) list of patient complaints that could be treated in the home/ community, 2) categories of complaints that could be used to form individual treatment pods, 3) list of the kit required for each treatment pod (i.e. to treat the individual complaints), 4) identification of barriers to delivery of healthcare in the community, 5) Solutions to these barriers.

Bristol participants were given Loughborough findings to review and critique which complaints should and should not go to hospital (Jones et al, 2008a).

LEICESTERSHIRE COUNTY AND RUTLAND PRIMARY CARE NHS TRUST	EAST MIDLANDS AMBULANCE SERVICE NHS TRUST
1) Deputy Chief Executive and Medical Lead	7) Assistant Director of Corporate Services
2) Strategic Lead for Out of Hours Services	8) General Manager of Fleet
3) Change Manager for unscheduled care	9) Service Improvement Manager
4) Chairman of PCT	10) Back Care Advisor
5) Nurse Advisor Triage	11) Emergency Care Practitioner
6) Nurse Advisor	12) Service Improvement Manager

Table 14
Participants at the Loughborough workshop

UNIVERSITY BRISTOL HOSPITAL NHS TRUST	BRISDOC	GREAT WESTERN AMBULANCE SERVICE NHS TRUST
1) Change Nurse, Emergency Department	5) Out of Hours GP	9) Emergency Care Practitioner
2) Registrar	6) Nurse Practitioner	10) Emergency Care Practitioner
3) Research Nurse	7) Nurse Practitioner, Walk in Department	
4) Emergency Nurse Practitioner	8) Nurse Practitioner, Walk in Department	

Table 15, above
Participants at the Bristol workshop

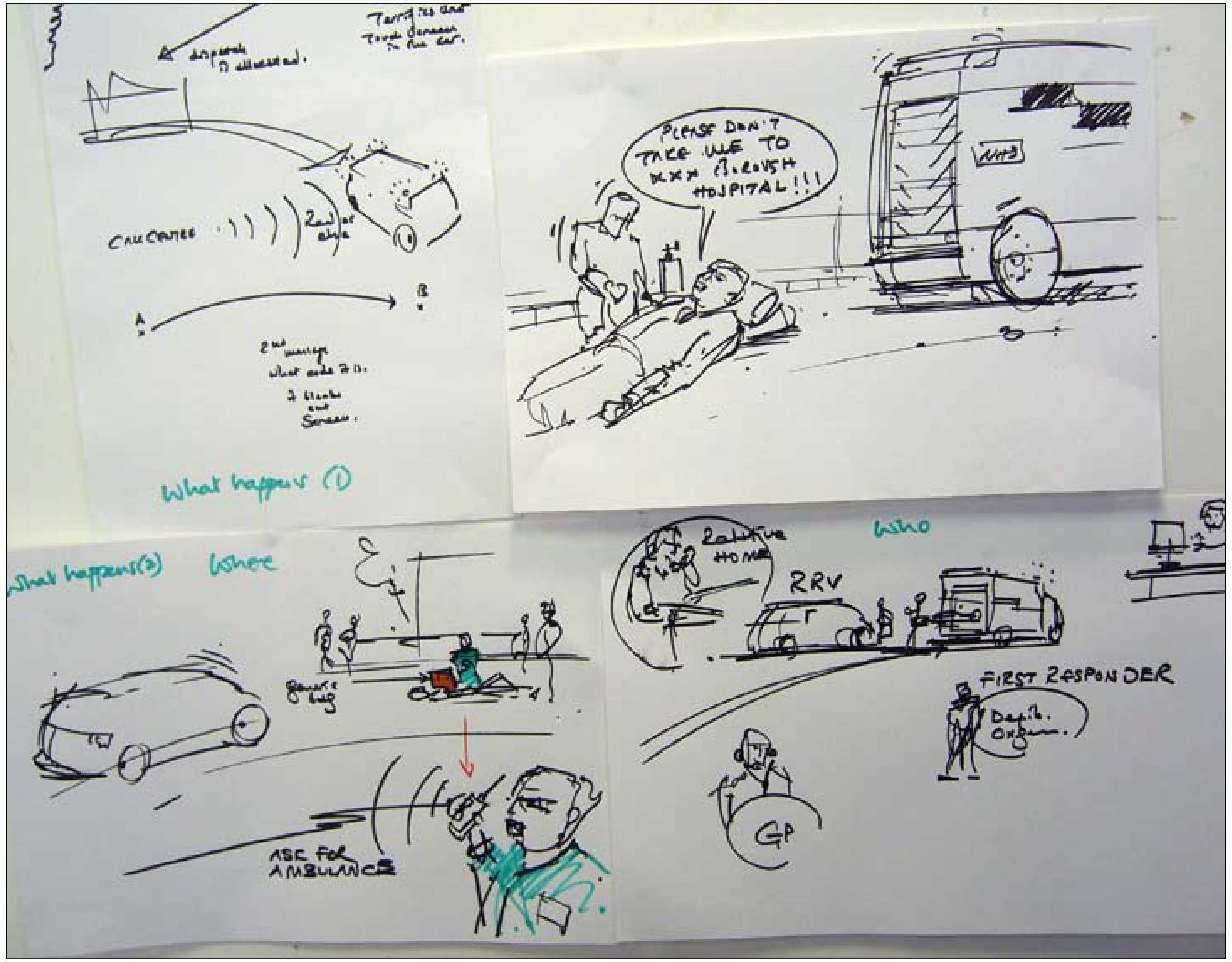


Figure 28, right
Visual representation of current emergency care response

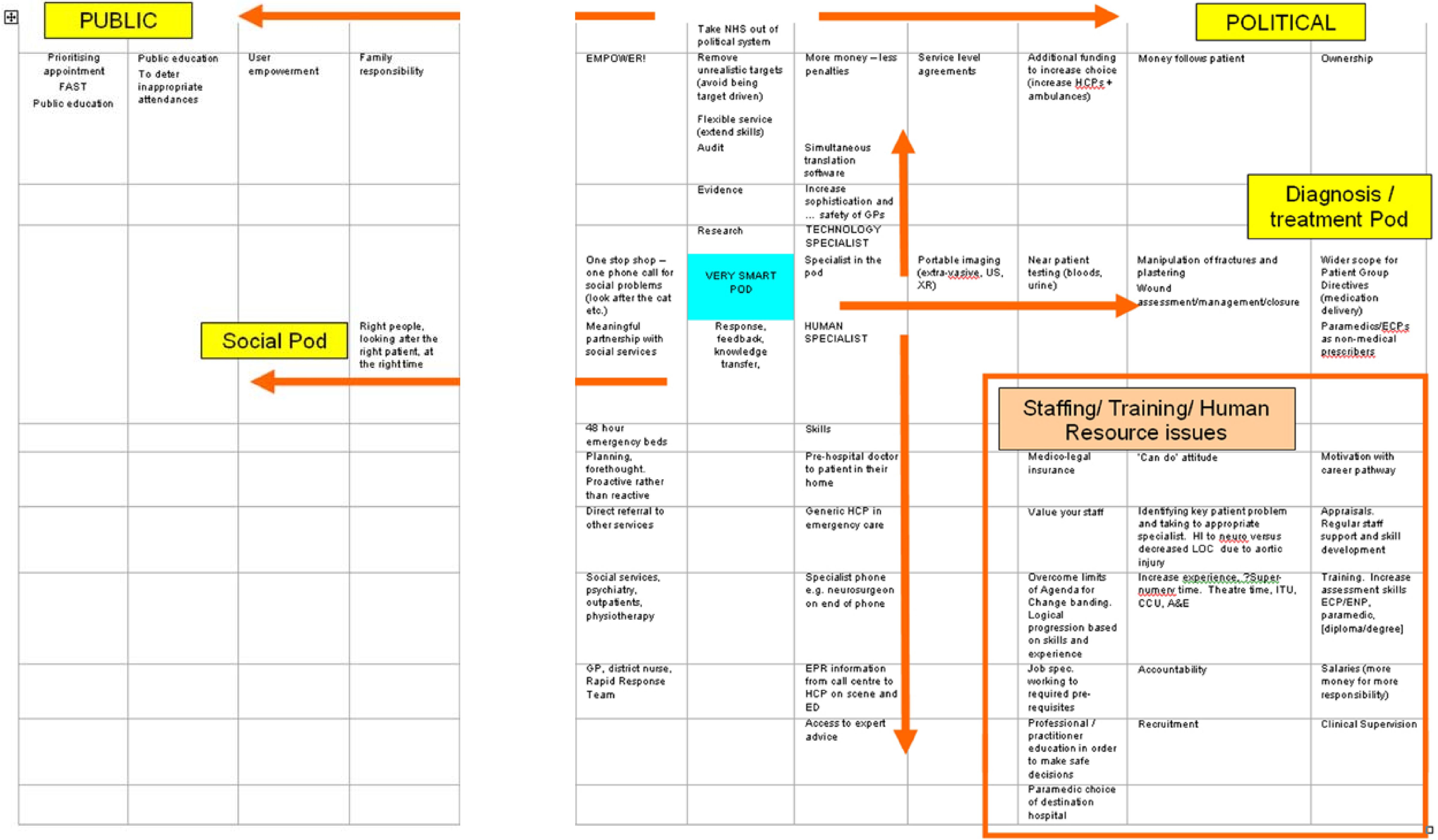


Figure 29
Cluster of the 2007 workshop results across the categories – public; political; social; diagnosis/treatment; and staffing/ training/human resources – to give a mapping for the Smart Pods concept.

Figure 30
A vehicle designer's sketch neatly captures an idea generated in a stakeholder workshop.

Literature Review, Executive Summary

Technology and Innovation

The identification and selection of emerging technologies and the management of the innovation process within the UK healthcare industry are rising up the healthcare agenda. Furthermore, expectations of healthcare are changing; patients are becoming increasingly informed, there is growing pressure on policy makers and health decision-makers to not only provide the latest healthcare technologies, but also to change the nature of health delivery to enable access to a wide range of services within the community as well as in hospitals and specialist centres (Department of Health, 2006b). From his study of the UK healthcare system, Wanless (2001) has called for the rapid and consistent diffusion of technologies throughout the healthcare system. This has been supported by a recent initiative: The 'Healthcare Industries Task Force' (HITF). Such UK Government schemes indicate growing awareness of the problem and recognition that there is not a single solution. Through analysis there is much scope for improving innovative capacity and the initiation and uptake of technologies.

Emergency care services are faced with the triple hurdle of delivering a service that is more responsive, more resource efficient, but that also employs the latest medical technologies. For commissioners of emergency care, this calls for a need to develop services that respond not only to changes in local needs, but also an evolving healthcare sector. The resulting move towards community-based services has led to transformations within ambulance trusts, resulting in an increasing number of frontline clinicians such as Emergency Care Practitioners (ECPs) and paramedics who are able to assess patients within their communities, or over the telephone, often alleviating the need for hospital-based care. Such transformations in emergency care services have highlighted the need to identify and harness technologies that will support the delivery of "services to people rather than people to services" (Department of Health, 2006: p.6). The aim of the Smart Pods project is to consider how such a reconfiguration can be enabled, looking towards the redesign of the emergency care system. Reconfiguration of the system will not only require employing new healthcare technologies, but will also require consideration of the strategies required to support this process of innovation.

The main focus of this literature review is the management of technology and innovation within the healthcare sector and, more specifically, within emergency care services.

Report framework
The specific objectives of the literature review are:

- To develop an understanding of the main procurement functions and issues relating to the supply of new technologies into the English healthcare sector.
- To examine the nature and process of innovation
- To assess the importance of understanding innovation in healthcare

By examining existing knowledge, we aim to build an understanding of the introduction and selection of technology and innovation within the context of the UK healthcare industry by addressing some of the most salient aspects relating to the process of innovation.

The review of the literature explored a wide variety of sources prior to the identification and collation of relevant publications. The main sources were electronic databases of academic and practitioner publications, websites of professional associations, and academic conference proceedings.

Literature Review, Executive Summary

Urgent and Emergency Care

The NHS is divided into primary and secondary care providers. Primary care providers are the first point of contact for patients and are responsible for the general health of the population. They include GPs, Pharmacies, Opticians and Dentists. Secondary care providers (acute hospitals and ambulance services) deliver elective (planned) or emergency services usually at the point of transportation or in hospitals (NHS, 2009).

Emergency and urgent care is located between the primary and secondary care sectors: urgent care is traditionally provided by the primary care sector and emergency care by the secondary care sector. There is an increasing overlap for the provision of emergency and urgent care between the two sectors. The Department of Health defines urgent care as 'the range of responses that health and care services provide to people who require – or perceive the need for – urgent advice, care, treatment or diagnosis' (Department of Health, 2006). 'Urgent care is when medically necessary services are provided in order to treat an unexpected illness or accidental injury which is not threatening to life or limb' (IBX, 2009). Emergency care is provided to patients with life threatening conditions requiring immediate medical intervention (Medtronic, 2009).

The ambulance service has traditionally provided emergency care, focusing on transportation of patients to hospitals. With recent changes in the NHS (Department of Health, 2005b) the Emergency Care Practitioner (ECP) service is moving away from emergency care and towards urgent care by providing treatment and discharging patients in their own homes. This bridges the gap between the primary and secondary healthcare sectors.

Research suggests that patients have found difficulties in entering the emergency and urgent care system and making correct treatment choices (Lee et al, 2002; Smith, 2008) and negotiating access to services (Richards et al. 2007; O'Cathain et al, 2007; Egbunike et al, 2007). They value co-ordination between services; good communication with health professionals; and speedy access (Richards et al, 2007; O'Cathain et al, 2007). Research has found that changes made to GP provision and out of hours (OoH) care in the UK have led to patients using services inappropriately (Benger and Jones, 2008; Richards et al, 2007), with a resultant shift away from GP treatment to emergency departments (EDs) (Benger and Jones, 2008).

However, there is evidence to suggest that 50% of patients attending EDs may not need follow up treatment (and are discharged from the ED) (Pennycook et al, 1991) and that up to 66% of ED patients could be treated by GPs (Lee et al, 2002). As a result, EDs are becoming overcrowded with inappropriate attendance and lengthy waiting times (Smith, 2008; Snooks et al, 2002; Welsh Assembly Government, 2008).

There are an average of 246 new attendances at major EDs per 1000 population, with at least 25% not requiring these facilities (Williams et al, 1997). At the primary care interface, there is concern that older patients and people with complex needs do not become alienated due to recent changes (Richards et al, 2007), for example a lack of resources to provide intensive care by district nursing teams (Edwards and Dyson, 2003). Many ambulance services want to develop alternative responses rather than dispatching an emergency vehicle to all 999 calls (Snooks et al, 2002; 2004a). Research has identified concerns about the appropriate use of ambulance services for both clinical and transport issues (Palazzo et al, 1998; Billitier et al, 1996; Richards and Ferrall, 1996).

Alternatives to emergency department attendance
A range of initiatives have been considered in order to move primary care patients away from the secondary care sector, for example, closer liaison between senior medical staff and ambulance services (Pennycook et al, 1991); tele-nursing (Marsden, 1995); NHS Direct (Department of Health, 1997); OoH nurse-led primary care telephone service (Department of Health, 1997); a review of priority dispatch systems (Gray and Walker, 2008); and advanced support (such as ECPs, treat and refer protocols, physician-response unit) from ambulance services (Snooks et al, 2002; Bell et al, 2006). Evidence shows that altering working practices can improve delivery of care and reduce hospital attendances and preventable ambulance journeys (Bell et al, 2006).

A Government white paper published in 1995 (Marsden, 1995) recommended the introduction of a nurse-led telephone triage system to dispatch emergency ambulances according to clinical needs (Palazzo et al, 1998). This has been found to be a suitable method for managing many category C calls by allowing the nurse triage to make an informed decision about whether face-to-face treatment is necessary (Dale et al, 2003; 2004). NHS Direct provides another alternative by delivering information about health, illness and the NHS, it has been reported to be well received, offering patients necessary reassurance (Department of Health, 1997; O'Cathain et al, 2000). OoH nurse-led primary care telephone consultation has been found to reduce the demand on ED admission and has the potential to reduce emergency care costs in the longer term (Lattimer et al, 1998; 2000).

Treat and refer protocols allow ambulance staff to leave patients at the scene and/or refer them to other healthcare sectors (Snooks et al, 2004b and 2005). Initial reviews suggest that they may increase the job cycle time and some safety issues have been identified, but patients response was positive. A UK study asked ambulance staff to predict which patients would required hospital admission and found that they correctly identified most patients who would be able to leave the hospital. Further work was recommended to ensure the safe triage of patients to alternative care destinations (Clesham et al, 2008). A Physician Response Unit (pre-hospital care physician and an ambulance technician or paramedic) has also been piloted and found to provide a higher level of care than the traditional ambulance service with a positive impact on response times (Bell et al, 2006), but no information was reported for clinical outcomes.

The Ambulance Service Network (2008) has a vision for the future with an integrated, seamless service across primary, secondary and community care, and a range of urgent care services available 24 hours a day, seven days a week. In many ambulance services the ECP role has been established and supports this vision by providing treatment and diagnosis in the community and offering a clinically effective alternative to the standard ambulance transfer and ED treatment for elderly patients with acute minor conditions (Department of Health, 2005; Mason et al, 2007a). An extension of this system can be seen with, for example, a blood testing service which allows blood to be taken in the community and tested in hospital (NHS Confederation, 2009). The impact of mobile care has been evaluated with some schemes receiving a high level of success (Moore, 2008; Perez et al, 2006; Sartor et al, 2004) and others having a lower impact, such as mobile stroke services (Langhorne et al, 2005; Dey et al, 2005). It seems that the success of alternative urgent care services may be related to the level of required care.

Literature Review, Executive Summary

Socio-Cultural Issues

The Smart Pods initiative has developed against the general backdrop of major organisational and cultural changes within the NHS and healthcare systems. This summary hightlights the key points arising from a comprehensive review of the literature pertaining to the organisational, socio-cultural and political contexts shaping the development of new technologies and systems for delivering urgent and emergency healthcare within the home and community.

The concept of 'taking healthcare to the patient' seems to be a valued objective within healthcare, given the increasingly evident limitations of the traditional focus on hospital-based urgent and emergency care. The history of the ambulance and emergency care services, (see Mobility Overview, page 31 and Treatment Overview, page 69), highlights how the trajectory of urgent and emergency services has been tightly linked to a particular conception of healthcare delivery and technology development. Deeply held assumptions about the role of hospitals and the best means of treatment continue to inform the technology of the ambulance and urgent and emergency care services and shape citizens' and healthcare workers' views and actions. If the ideal of 'closer to patient' healthcare is to be realised, there will need to be a change in the cultures, attitudes and systems that support current modes of healthcare delivery. However, as this review highlights, change is not always straightforward and may entail obstacles and have unforeseen impacts.

Conclusions and recommendations

At the project's conception, five groups who will directly benefit from the project were identified. These are: patients (who will benefit by not being transported to an ED); the NHS (which will benefit from the receipt of the technologies); the 'general public' (who will benefit from, among other things, being able to remain in their homes); professionals (who will benefit from being able to utilise the new technologies, which will complement their training for expanded roles); and manufacturers.

This review has highlighted some of the issues that might be associated with these assumptions, including the importance of critically evaluating the notion that the public is an homogenous group. Indeed, as has been argued, such an initiative has the potential to impact unevenly upon a variety of patient groups, some of whom may be especially vulnerable to changes in the provision of emergency care and for whom the ED may provide a unique and expanded range of services.

Professionals are a heterogeneous group and there should therefore be caution with regards any assumption that professionals will wish to work with these new technologies; even amongst those who are interested in working with the Smart Pods, there is likely to be a need for considerable training and mentoring. Guidelines to assist workers in their new roles will also need to be developed, as will methods to assess the impact of the initiative on staff morale and relationships, stress levels, physical health and job satisfaction, with a view to ensuring that staff are not adversely affected by the changes.

Informed consideration must be given to the implementation of any new technologies and policies aimed at diverting attendances from accident and emergency care, especially where there is a possibility that vulnerable groups will be unevenly impacted by the changes. As Bywaters and McLeod (2003) argue, EDs are not simply sites for the provision of acute and emergency care. They also operate for 'the preventive identification of people with a wide range of unmet social and health needs' (Bywaters and McLeod 2003:135) and serve as a 'social welfare institution' (Gordon 1999).

Any model designed to divert users from the accident and emergency care system must remain cognisant of the diverse function of the ED if it is not to impact unevenly across the British population.

A summary of some issues for consideration in response to the range of challenges examined in this review are set out below (see table 7).

Key organisational challenges
1) Potential for increased burdens on staff at different points in the system
2) Potential for decreased staff morale and/or staff turnover
3) Possibility of staff resistance to changes – power / autonomy issues
4) Potential for mismatch between technologies, expectations and the adequacy of ambulance staff training
Key socio-cultural challenges
1) The ED may function as a form of respite for some patients
2) Potential logistical issues in home/community treatment
3) Potential for patient resistance to non-traditional models of care
4) Home or community care can reconfigure space and place
5) Home and community care can adversely impact upon family members and/or family dynamics
6) Potentially uneven impacts upon specific patient groups (e.g., the aged; victims of Domestic Violence; the homeless)
7) Home or community-based care may not satisfy the full range of ED functions
8) New guidelines may need to be developed for triage assessment
Key political challenges
1) Possibility of variations in the level of political support
2) Possibility of variations in financial support for the project
3) Establishing and maintaining the commitment of policymakers, publics and key stakeholders

Table 16
Identifying the challenges

Potential approaches to key challenges
1) Involve staff in technological development at an early stage
2) Incorporate reflexivity into the research design
3) Examine technological design for 'scripts' or embedded assumptions
4) Determine how staff who work with Smart Pods will be selected
5) Ensure adequate training and mentoring for staff
6) Introduce methods for assessing the impact of the initiative on staff job satisfaction
7) Identify those groups most at risk of uneven impacts of the Smart Pods initiative
8) Consult widely with potentially impacted groups regarding research design
9) Minimise the uneven impacts of the Smart Pods initiative
10) Explore options for resourcing and logistical issues
11) Consider development of guidelines for triage assessment
12) Consider the role of Constructive Technology Assessment (CTA) or Real Time Technology Assessment (RTTA)

Table 17
Issues for consideration

Glossary

Advance Medical Priority Dispatch System (AMPDS)
Computer software used by ambulance service call takers that employs a series of questions designed to help prioritise calls.

Ambulance Service NHS Trusts
NHS Ambulance Trusts are responsible for providing emergency access to NHS healthcare services and in some cases provide transport for patients to get to hospital. There are currently 12 Ambulance Trusts, which are defined by geographic location.

Auto Identification Technology
This includes technologies such as barcodes and radio frequency identification (RFID), which are widely used to track objects through complex systems, such as supermarket distribution networks.

Clinical Telephone Advice (CTA)
Operational in the London Ambulance Service (LAS) only. CTA is used to reduce ambulance call-outs to non-emergency cases through a series of questions.

Cardiopulmonary Resuscitation (CPR)
Emergency medical procedure for people in cardiac or respiratory arrest. It is carried out by a person with adeqaute training and involves a combination of proceedures to maintain blood circulation around the body, such as chest compressions and lung ventilation.

Department of Health (DH or DoH)
A Government department that provides, 'health and social care policy, guidance and publications for NHS and social care professionals.'

Dual-Crewed Ambulance (DCA)
Typically a van conversion or box construction, these vehicles are deployed to all types of calls and are crewed by two practitioners or more. They carry advanced life support equipment for treating patients on-scene and transport patients to and from emergency departments.

Emergency Department (ED)
Also referred to as the accident and emergency department (A&E), this is the hospital department that provides initial and sometimes life saving treatment to patients before they are referred onto another department or discharged.

Fast Response Vehicle (FRV)
These are vehicles assigned to respond at high speed to emergency calls and get the pre-hospital clinician on-scene as quickly as possible. Vehicles used in this role include motorbikes, estate cars, multi-purpose vehicles (MPVs) and sports utility vehicles (SUVs).

Emergency Care Practitioner (ECP)
This group of pre-hospital clinicians utilise the skills of paramedics and other professionals (such as nurses) to support the first contact needs of patients in unscheduled care.

Emergency Doctor
Doctors with additional training in emergency and urgent healthcare for both adults and children. Most work in emergency departments, but some also provide pre-hospital care on a paid or voluntary basis, working with ambulance trusts or local voluntary schemes such as the 'British Association for Immediate Care' (BASICS).

Emergency Medical Technician (EMT)
Working alongside a paramedic, they give patients potentially lifesaving care at the scene and get them to hospital as soon as possible. They are able to deal with a wide range of different conditions and situations.

General Practitioner (GP)
A medical practitioner who specialises in family medicine and provides primary care. Consultation is carried out in a practice, over the telephone, or in the patient's home. Some also work with local ambulance services and BASICS schemes to provide pre-hospital care.

NHS Direct
This 24-hour telephone service provides urgent care services over the phone, response to health scares, support for patients with long-term conditions, out of hours support for GPs and dental services, pre and post operative support for patients and remote clinics via telephone.

ORCON (Operational Research Consultancy)
ORCON was developed in 1974 in the UK as a standard for monitoring ambulance service performance.

Paramedic
Often the senior member of a dual-crewed ambulance and assisted by an Emergency Medical Technician. They also work on their own, deployed on foot, bicycle, motorbike or rapid response vehicle. They are qualified to use high-tech equipment, such as defibrillators, spinal and traction splints, and administer oxygen and drugs.

Patient Report Form (PRF)
Form filled out by pre-hospital clinicians after delivering a patient to hospital, or treating and discharging on-scene.

Pre-Hospital Clinician
This group includes Emergency Care Practitioners, Emergency Medical Technician, Paramedics and Emergency Doctors.

Primary Care Trust (PCT)
These trusts are part of the NHS and are responsible for providing healthcare and social services locally. They control roughly 80% of the NHS budget.

Rapid Response Vehicle (RRV)
See 'Fast Response Vehicle (FRV)'.

Responder Bag
Portable treatment pack carried by Paramedics, EMTs and ECPs, which contains essential kit and consumables.

Social Services
Responsible for health and welfare including care for people with stress related issues, financial or housing problems, disabilities and those needing help with daily activities.

Walk-In Centre (WIC)
Introduced in 2000, this NHS service aims to provide rapid access to health advice and treatment on a drop-in basis. There are currently around 80 in England.

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